



INSTRUCTION MANUAL

for

for

Panoramic SPECTRUM ANALYZER Model SPA-4a



Manufactured by



THE SINGER MANUFACTURING COMPANY

915 PEMBROKE STREET • BRIDGEPORT 8, CONNECTICUT





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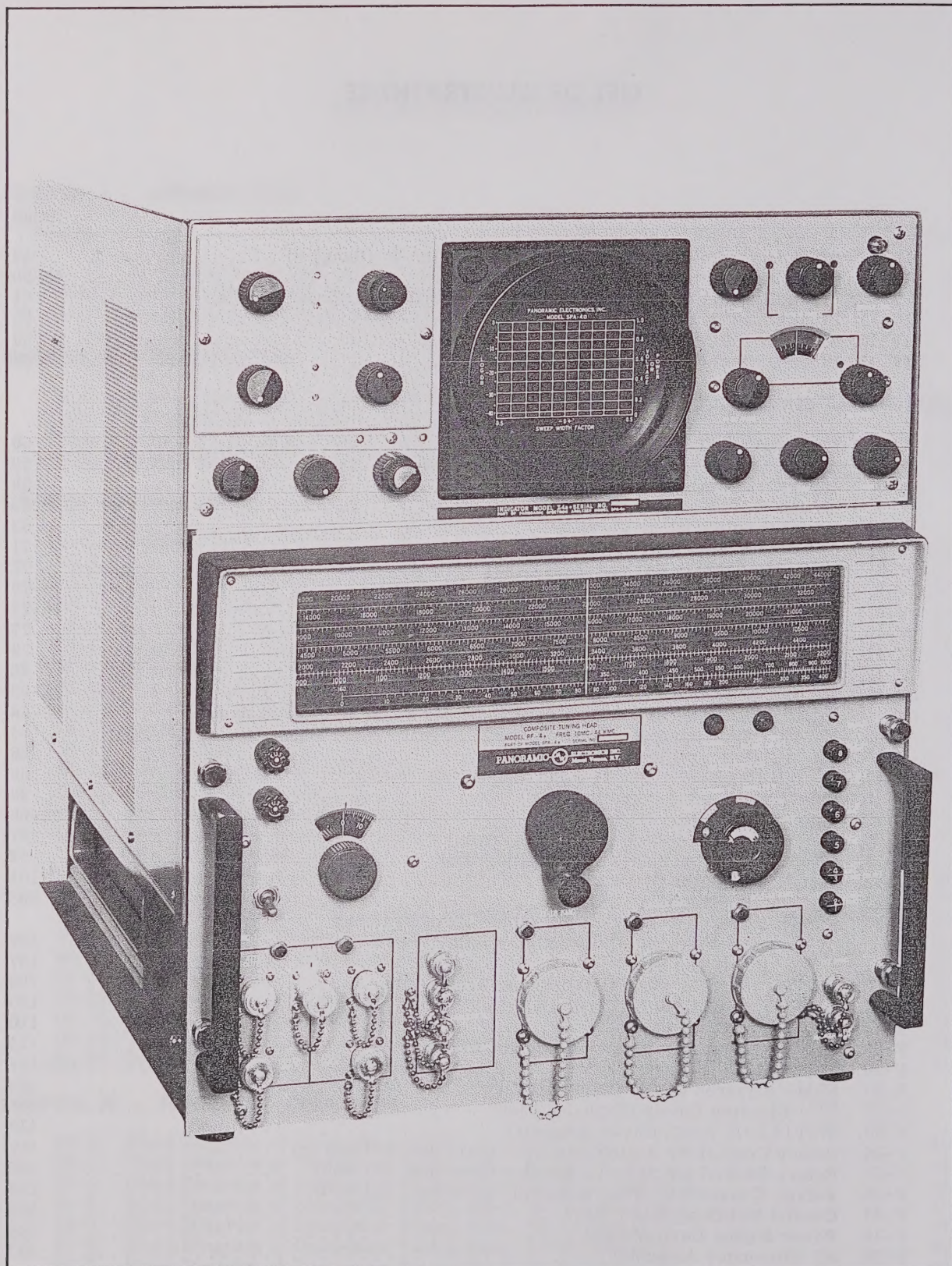
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Panoramc Spectrum Analyzer, Model SPA-4a.

CHAPTER I

INTRODUCTION

I-1. GENERAL

This Instruction Manual has been prepared to assist in the installation, operation, and maintenance of the Panoramic Spectrum Analyzer, Model SPA-4a.

No attempt to operate the equipment should be made until the operator is thoroughly familiar with the information contained in CHAPTER III - OPERATION.

I-2. APPLICATIONS

The uses detailed below represent but a few of the many applications of the Panoramic SPA-4a Spectrum Analyzer. Inquiries are invited regarding the applications of this instrument to particular requirements.

Visual examination of oscillator or transmitter performance.

Monitoring communications channels and radar frequencies.

Pulsed signal analysis.

Analysis of spectra associated with AM, FM, and PM signals.

Direct reading of power points and nulls.

Studies of malfunctioning of microwave equipment (e.g., spurious signals, instabilities, microphonic effects, etc.)

Noise spectrum studies.

Harmonic and other out of band measurements.

Examination of CW signals for frequency drift, incidental FM, squegging, etc.

Examination of dynamic operating characteristics of microwave tubes.

Checking for RF leakage and radiation.

Determining presence and frequency of RF signals.

As a sensitive receiver to measure characteristics of microwave components or circuits (such as insertion loss measurements, VSWR measurements, etc.).

I-3. EQUIPMENT SUPPLIED

The following units constitute a complete set:

<u>Description</u>	<u>Quantity per Equipment</u>
Panoramic Microwave Spectrum Analyzer, Model SPA-4a, comprising: . . . 1	
Indicator Unit, Model I-4a	
Composite Tuning Head, Model RF-4a (10 MC - 44 KMC)	
Power Supply	
Adaptor, Coax to Waveguide 8.2 to 12.4 KMC	1
Adaptor, tapered transition, waveguide to waveguide, X Band to KU Band	1
Jumper, Attenuator.	1
Line Cord	1
Alignment Tools	1 set
Allen and Spline Wrenches	1 set

I-4. GENERAL DESCRIPTION

The Model SPA-4a Panoramic Spectrum Analyzer includes an i-f Indicator section, Model I-4a, and a Composite Tuning Head, Model RF-4a. The Indicator, Model I-4a, is basically a broadband scanning heterodyne Panoramic receiver which combines high sensitivity, exceptional selectivity, simplicity of operation and reliability. The Composite Tuning Head, Model RF-4a, converts incoming signals to the acceptance slot (160 MC $\pm$ 35 MC) of the broad-band i-f Indicator. Displays are presented on a 5 inch cathode ray tube on which power, linear voltage, or logarithmic voltage versus frequency is plotted.

The Composite Tuning Head, Model RF-4a, includes a precise direct reading slide-rule dial, 8 frequency bands (using 2 klystrons and 1 triode local oscillator) and 4 wide-band crystal mixers. The center frequency is precisely read in megacycles with an accuracy of $\pm 1\%$ or ± 2 MC (whichever is greater). The RANGE switch automatically

couples in the correct crystal mixer for the band desired.

The frequency band under observation is repeatedly scanned at a selected rate of 1 to 60 CPS. Sweep width (dispersion) is continuously variable from 0 to 70 MC (± 35 MC) and 0 to 5 MC on the two sweep width ranges. Either wide-band observation of a spectrum segment as large as 70 MC or highly selective analysis of small sections is readily accomplished. The 0 to 5 MC sweep width range ensures adequate stability with narrow spectra, such as those due to broad pulsed RF signals. Both swept local oscillators operate on fundamentals thus simplifying the circuitry and eliminating the spurious effects of frequency multipliers. The frequency components of the input signal appear along the linearly calibrated horizontal scale of the CRT screen as well-defined vertical deflections.

Frequency differences on the display may be determined quantitatively by two successive positionings of the calibrated internal marker pip.

The internal marker frequency is controlled by two calibrated dials, one for each dispersion range. For broad dispersions, a 0 to ± 40 MC range is furnished. The other marker range is 0 to ± 3 MC. An indicator on the front panel lights when the marker is on to avoid confusion with input signal pips. An external generator may be connected to the front panel MARKER MOD connector to provide additional markers which are sidebands of the internal marker oscillator. The frequency of the external generator used to modulate the internal marker may be set from approximately 10 KC to 2 Mc for convenient marker spacing. Sweep width calibrations can be made precisely with marker modulation since the external generator alone determines the spacing between successive marker pips.

Respective amplitudes of signals may be measured by reading along any of three vertical scales: power (square), linear voltage or logarithmic voltage. The power scale is convenient for such uses as power point locations in pulsed RF signals (half-scale deflection equals half power) and critical comparisons between signals of nearly similar amplitudes.

High sensitivity and extended linear dynamic amplitude range (low residual distortion) due to low internal noise are salient SPA-4a design features.

A 100 db range adjustable attenuator for input frequencies up to 10.88 KMC is provided. External attenuators may be employed at higher

frequencies. A GAIN control provides for smooth adjustment of the vertical deflections for all frequencies.

A 50 ohm coaxial (Type N) input terminal is provided for signals from 10 MC to 10.88 KMC. Three waveguide inputs are provided for 10.88 KMC to 44 KMC signals. Above 10.88 KMC, waveguide inputs sharply attenuate unwanted frequencies below cutoff as in harmonic product measurements thus providing considerable pre-selection.

Provisions for widely variable scanning rates and continuously adjustable i-f bandwidth resolution are included. Rates from 1 to 60 sweeps per second may be selected in free-running mode or with synchronization to power line or by external source. The sweep CALibrate provision displays sweep rate versus line frequency and aids in setting up line synchronized sweeps. Line synchronized sweep rates aid in visually "stopping" hum modulation which may mask other modulations of the signal. Stationary synchronized displays with a very wide range of pulse frequencies may be obtained. Skipping or other irregularities in a pulser are immediately apparent. Scanning rates may be adjusted for a fairly large number (30 - 100) of distinct spikes during each scan interval. When analyzing signals with closely spaced sidebands, as in narrow band FM and AM, the lower scan rates are used to take full advantage of the great resolving capabilities of the analyzer. The IF BANDWIDTH control may be adjusted for optimum visual separation once the sweep width and sweep rate are selected for a particular measurement. With narrow pulses, the power points are relatively far apart in the spectrum and the i-f bandwidth is increased to provide adequate amplitude response.

The very low threshold signal level of the SPA-4a permits a relatively large linear voltage swing at the input between minimum discernible and overload levels. This wide dynamic range is most important when extremely narrow pulses or other broad band signals are measured. For such dispersed energies, the analyzer, at any instant, "looks at" only a very small portion of the total input signal. The ability to measure low levels in small spectrum segments without overdriving the input circuitry is vital to broad band analysis. For input levels less than -40 dbm, the SPA-4a operates with a high degree of linearity, providing essentially spurious free spectrum analysis.

I-5. ELECTRICAL CHARACTERISTICS

FREQUENCY RANGE: 10 MC to 44,000 MC in 8 Ranges (selected by a 6-position push-button RANGE switch). See Table I-1.

TABLE I-1. FREQUENCY RANGES

Band	Frequency	Type Operation	Input Connector	REF Sensitivity* (Ser. nos. 151-250)	RF Sensitivity* (Ser. nos. 251-up)
1	10 MC - 420 MC	Fund.	Type N	-100 to -110 dbm	-100 to -110 dbm
2	350 MC - 1,000 MC	2nd har.	Type N	-95 to -105 dbm	-95 to -105 dbm
3	910 MC - 2,200 MC	Fund.	Type N	-100 to -110 dbm	-105 to -110 dbm
4	1,980 MC - 4,560 MC	2nd har.	Type N	-90 to -100 dbm	-100 to -105 dbm
5	4,500 MC - 10,880 MC	Fund.	Type N**	-90 to -100 dbm	-100 to -110 dbm
6	10,880 MC - 18,000 MC	2nd har.	UG-419/U***	-85 to -100 dbm	-95 to -105 dbm
7	19,000 MC - 26,400 MC	3rd har.	UG-425/U	-70 to -100 dbm	-85 to -95 dbm
8	26,400 MC - 44,000 MC	4th har.	UG-381/U	-60 to -80 dbm	-75 to -90 dbm

* Measured when signal and noise equal 2 x Noise (sweep rate, sweep width and i-f bandwidth adjusted for narrow band, highly selective analysis).

** Adapter supplied: coax to waveguide 8.2 - 12.4 KMC. UG-39/U Flange.

*** Adapter supplied: Tapered transition, waveguide to waveguide, X Band to Ku Band. UG-39/U to UG-419/U Flanges.

LOCAL OSCILLATORS:

6AF4A - Ranges 1 and 2
6BM6 - Ranges 3 and 4
5721 - Ranges 5 through 8

+24 DBM at 50 ohms into the attenuator input
(to 10.88 KMC).

-40 DBM direct (to avoid distortion due to dynamic overload).

RF INPUT MIXERS:

1 - Coax: 10 - 11,000 MC
3 - Waveguide: 11,000 - 44,000 MC

SPECTRUM DISPLAY:

On 5-inch CRT (5ADP1 or 5ADP7 as requested) with scale lighting and camera mount bezel.

RF ATTENUATION:

All Coax inputs: approximately 100 db range; adjustable.
Waveguide inputs: External Attenuators available.

AMPLITUDE SCALES: (vertical CRT deflections)

40 DB Logarithmic Voltage, Linear Voltage and Power (square).

RF INPUT IMPEDANCE:

50 ohms, nominal.

Continuously variable from:
0 to 70 MC (wide-band).
0 to 5 MC (Narrow-band).

RF TUNING SCALE ACCURACY:

$\pm 1\%$ or ± 2 MC, whichever is larger. Slide rule scales show all frequencies.
The scale in use lights up.

Minimum useful dispersions: (Limited by incidental fm in SPA-4a local oscillators). See Table I-2.

RESOLUTION (3 DB i-f bandwidth):

MAXIMUM RF POWER INPUT:

Continuously variable from 1 KC to 80 KC.

TABLE I-2. MINIMUM USEFUL DISPERSIONS

Range	Frequency Range	Typical Minimum Useful Dispersion
1 & 2	10 MC - 1,000 MC	15 KC
3	910 MC - 2.2 KMC	20 KC
4	1,980 MC - 4,500 MC	30 KC
5	4,500 MC - 10,880 MC	40 KC
6	10,880 MC - 18,000 MC	80 KC
7	18,000 MC - 26,500 MC	120 KC
8	26,500 MC - 44,000 MC	160 KC

SWEEP REPETITION RATE:

Continuously variable from 1 CPS to 60 CPS.
Synchronization from line or external source
or free running.
Calibration provisions for repetition rate.

MARKER FREQUENCY:

Variable frequency to calibrate frequency
dispersion:

70 MC (Wide) -0 to ± 40 MC continuously
variable; Divisions every
2.5 MCS, Differential ac-
curacy ± 500 KC.
5 MC (Narrow) -0 to ± 3 MC continuously
variable, Divisions every
250 KC, Differential ac-
curacy ± 50 KC.

MARKER MODulation input (used with external
signal generator): 10 KC - 2 MC. Provides
sideband marker pips on either side of main
internal marker pip with spacing determined
by signal generator frequency.

AUXILIARY OUTPUTS:

SYNCHROSCOPE: Detected signal envelope,
amplified 60 db, for monitoring of signal
modulation waveforms on external oscil-
loscope.

HORIZONTAL, VERTICAL and Z AXIS out-
puts are also available on units bearing
serial numbers 251 and up.

POWER SOURCE:

115 V or 230 V $\pm 10\%$ 50 - 60 CPS single
phase (equipment normally wired for 115 V).

POWER CONSUMPTION:

800 watts maximum.

I-6. PHYSICAL CHARACTERISTICS**a. WEIGHTS.**

Description	Weight
Model SPA-4a, Cabinet Mounted, (including Composite Tuning Head, Indicator Unit and Power Supply, and Cabinet)	160 lbs
Model SPA-4aR, Rack Mount Style	170 lbs

b. DIMENSIONS.

See Figs. II-2 and II-3 for complete dimen-
sional data.

I-7. FRONT PANEL CONTROLS

The following paragraphs outline the functions of
the front panel controls, inputs and indicators of
the Composite Tuning Head, Model RF-4a and the
Indicator, Model I-4a.

a. COMPOSITE TUNING HEAD, MODEL RF-4a.

1. **POWER.** This switch controls the AC line
power input to all filament and B+ transformers
except the Klystron high-voltage transformer.
The POWER switch controls the Klystron by
actuating a 60-second delay relay in the trans-
former primary circuit. The POWER indicator
glows when AC power is applied to the equipment.

2. **RANGE.** A six pushbutton switch is used
to set the Model SPA-4a to the desired frequency
range. Each pushbutton switches in the appro-

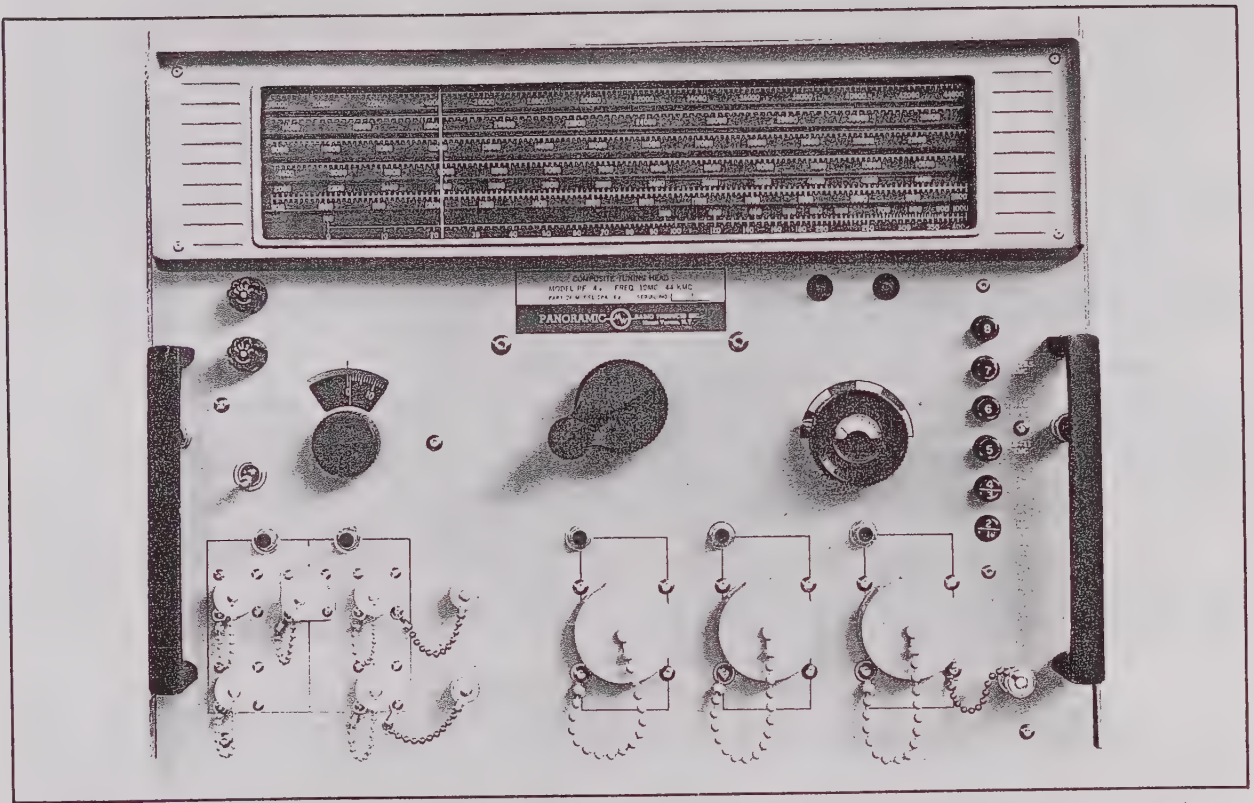


Figure I-1a. Front Panel, Composite Tuning Head, Model RF-4a (Serial Numbers 151 to 250).

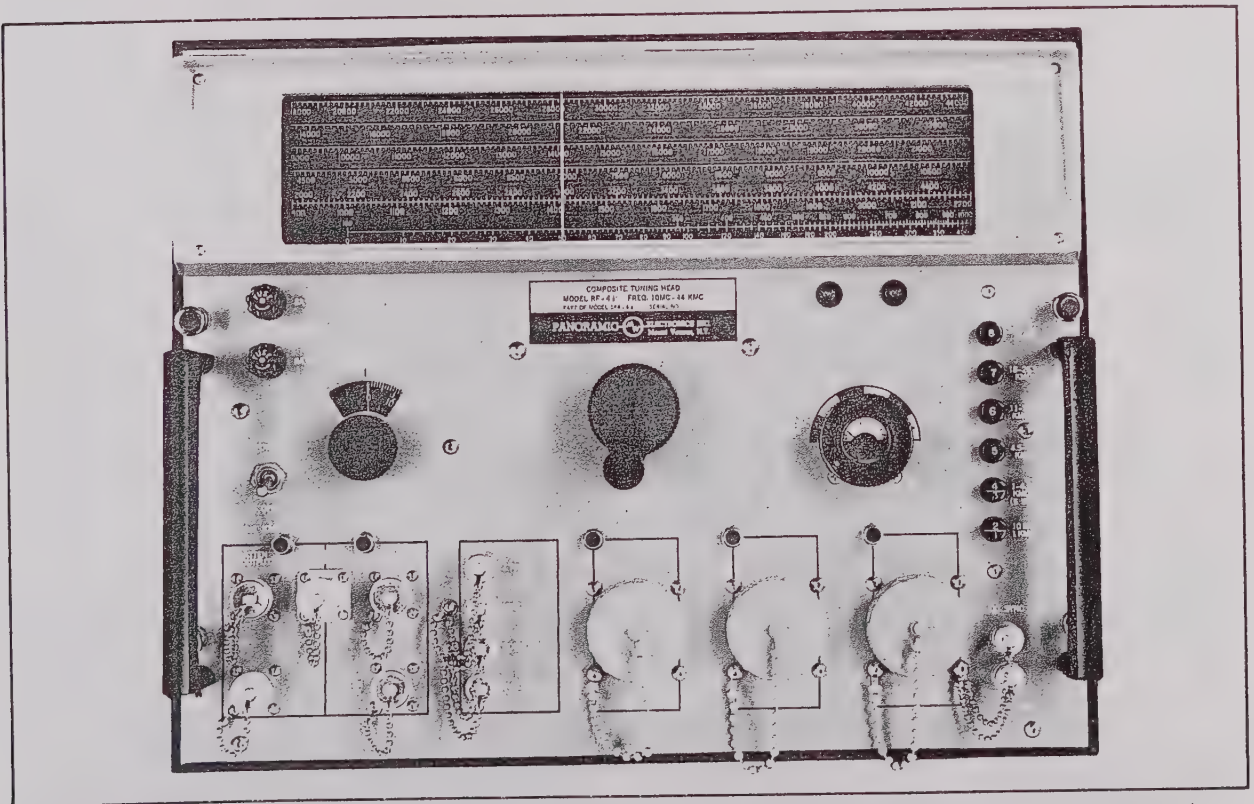


Figure I-1b. Front Panel, Composite Tuning Head, Model RF-4a (Serial Numbers 251 and up)

ropriate local oscillator and mixer to provide the appropriate frequency coverage. Indicator lamps, controlled by each pushbutton, light to indicate the appropriate INPUT and frequency tuning scale to be used.

The available combinations are listed in Table I-3.

3. TUNING MEGACYCLES. This control is used to vary the frequency of the local oscillator in use and to tune the desired test signal to the center of the Indicator CRT screen.

4. TUNING SCALE. The frequency of a signal appearing at the center of the Indicator CRT screen is read directly under the pointer on this scale. Only the tuning scale in use is illuminated. To determine the actual frequency of the test signal refer to Chapter III - OPERATION.

5. RF ATTENUATOR. This continuously variable control provides 100 DB of attenuation (above initial insertion loss of approximately 10

to 30 db) of input signals in the 10 MC to 1 KMC and 1 KMC to 11 KMC ranges. The dial scale reads in arbitrary units.

6. METER FUNCTION. This six-position switch, with its integral monitoring meter, is used to check system currents and voltages. The meter indicates information for the band in operation only. Meter indications for correct system operation are given in Table I-4, METER FUNCTION Indications.

7. INPUTS



To prevent amplifier overloading and possible crystal burnout, RF input power exceeding -40 DBM should not be connected to any direct input.

TABLE I-3. RANGE INDICATIONS AND INPUTS.

Range	Frequency	Inputs and Indicators	Dial Scale
2 1	10 MC - 1 KMC	DIRECT INPUT 10 MC - 11 KMC ATTEN INPUT* 10 MC - 1 KMC LOCAL OSC**	1 and 2
4 3	1 - 4.56 KMC	DIRECT INPUT 10 MC - 11 KMC ATTEN INPUT* 1 to 11 KMC LOCAL OSC**	3 and 4
5	4.56 - 11 KMC	DIRECT INPUT 10 MC - 11 KMC ATTEN INPUT* 1 to 11 KMC LOCAL OSC**	5
6	11 - 18 KMC	INPUT 11 - 18 KMC LOCAL OSC**	6
7	18 - 26.5 KMC	INPUT 18 - 26.5 KMC LOCAL OSC**	7
8	26.5 - 44 KMC	INPUT 26.5 - 44 KMC LOCAL OSC**	8
* See paragraph 5. ** When the LOCAL Oscillator indicator is glowing, B+ or high voltage is being supplied to the local oscillator. There is a 60 second delay after the POWER switch is turned on before the LOCAL Oscillator indicator glows. There is a 5 second delay before the indicator glows when switching to Range 3/4 from any other Range.			

TABLE I-4. METER FUNCTION INDICATIONS.

Position	Measures	Indication
CRYSTAL BIAS	Crystal Bias Current at operating mixer	Any
KLYSTRON CURRENT	Anode Current of operating Klystron	.4 to .7
CATHODE V(olts)	Cathode Voltage of operating Klystron	Mid-scale
REPELLER V(olts)	Repeller Voltage of operating Klystron	Mid-scale
+300 V(olts)	System 300 volt B+ supply	Mid-scale
+200 V(olts)	System 200 volt B+ supply	Mid-scale

(a) DIRECT INPUT - 10 MC - 11 KMC. This input connector is used for signals below -40 dbm in the 10 MC to 11,000 MC range. (Ranges 1 through 5). The Waveguide (UG-39/U) to Coax (Type N) adapter is provided to permit connection of signals from waveguide sources in the 10 MC to 11 KMC range.

(b) ATTENUATOR INPUT - 10 MC - 1 KMC. This input connector is used when signals in the 10 MC to 1,000 MC range, which are to be analyzed, exceed -40 dbm. The Jumper Cable supplied with the equipment is used to connect the ATTENUATOR OUTPUT 10 MC - 1 KMC connector to the DIRECT INPUT connector. The required attenuation of the input signals is provided by the RF ATTENUATOR control. (See paragraph 5 above.) Signals with amplitudes as great as 250 mw or +24 dbm can be connected to this input.

(c) ATTENUATOR INPUT - 1 - 11 KMC. This input connector is used when signals in the 1,000 to 11,000 MC range which are to be analyzed exceed -40 dbm. The Jumper Cable supplied with the equipment is used to connect the ATTENUATOR OUTPUT 1 - 11 KMC to the DIRECT INPUT connector. A waveguide (UG-39/U) to Coax (Type N) adapter is provided to permit connection of signals from waveguide sources in the 8.2 - 11 KMC range. The required attenuation of the input signals is provided by the RF ATTENUATOR control. (See paragraph 5 above.) Signals with amplitudes as great as 250 mw or +24 dbm can be connected to this input.

(d) INPUT 11 - 18 KMC. Signals within this frequency range should be injected at this input. The waveguide to Type N or waveguide to waveguide (X band to KU band) adaptors supplied can be used to connect signal sources in the range 11 to 12.4 KMC to this input.

(e) INPUT 18 - 26.5 KMC. Signals within this range should be injected at this input. This is Range 7 of the SPA-4a.

(f) INPUT 26.5 - 44 KMC. Signals within this range should be injected at this input. This is Range 8 of the SPA-4a.

(g) MARKER MODULATION. An external oscillator signal can be introduced at this jack to permit small sweep width measurements to be made by means of sideband pips on either side of the marker pip.

(h) EXTERNAL SYNCHRONIZATION. An external sync pulse to synchronize the horizontal sweep with a recurrent signal can be injected at this jack. It is used when the CALIBRATION - SYNCHRONIZATION SELECTOR switch is on EXTERNAL position.

8. OUTPUTS

(a) SYNCHROSCOPE OUTPUT. The detected output of the 2nd i-f amplifier (75 MC) is made available at this jack. At zero sweep width, by using an external synchroscope, the waveform of an input pulse can be viewed. The impedance of this output is 93 ohms (nominal).

(b) Z AXIS. (Serial Nos. 251 and up) A high impedance output jack providing external blanking and intensifier voltages.

(c) VERTICAL. (Serial Nos. 251 and up) A high impedance output jack providing a duplicate output of the signal voltage appearing on the Indicator screen.

(d) HORIZONTAL. (Serial Nos. 251 and up) A high impedance output jack providing a duplicate output of the horizontal sweep voltage of the Spectrum Analyzer.

b. INDICATOR UNIT, MODEL I-4a.

The following controls are at the disposal of the operator. They are mounted on the front panel.

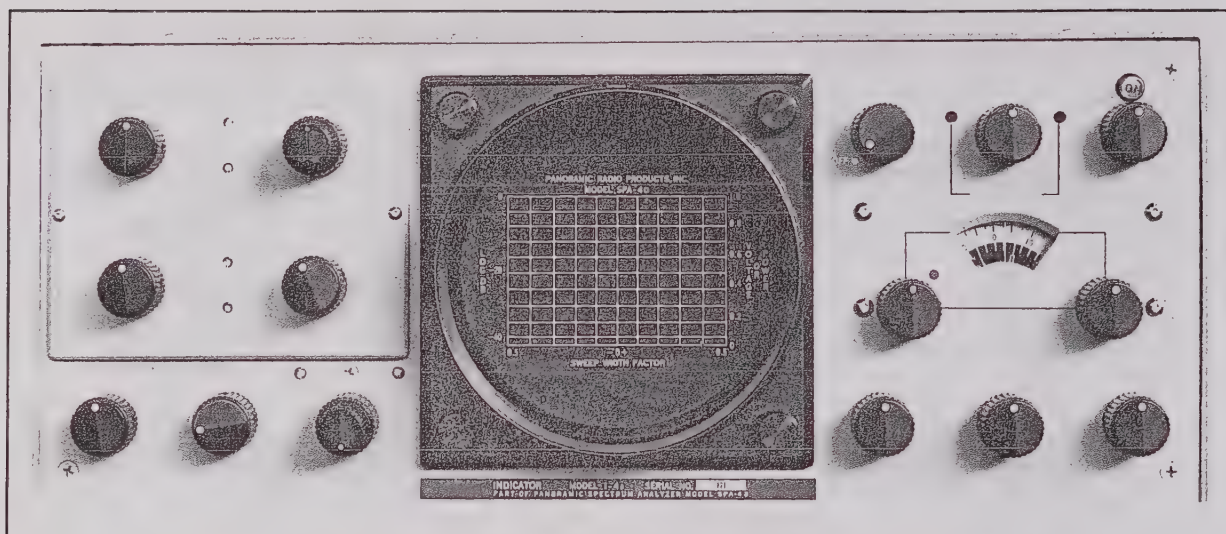


Figure I-2. Front Panel, Indicator Unit, Model I-4a.

1. **CALibration - SYNChronizationSElector** and **SYNChronization AMPLitude**. This is a dual concentric control. The **CALibration-SYNChronization SElector** is the outer knob. The **SYNChronization AMPLitude** control is the inner knob.

(a) CALibration-SYNChronizationSELector. This control is a three-position switch. In the CALibration position it provides for calibration of the sweep rate by injecting 60 CPS into the vertical deflection. In the LINE position, the sweep is synchronized with the power line frequency. The EXTERNAL position permits sweep synchronism with a suitable signal connected to the EXTERNAL SYNChronization connector on the front panel of the RF-4a.

(b) SYNCHronization AMPLitude. The amplitude of the sweep synchronizing signal is adjusted with this control to provide for CRT beam sweep synchronism. Maximum amplitude is obtained at maximum clockwise position.

2. SWEEP RATE. This control provides for continuously adjustable scanning rates between 1 CPS and 60 CPS. Counterclockwise rotation results in reduced scan rate.

3. GAIN. The amplitude of the deflections of the CRT screen is adjusted with the GAIN control. Clockwise rotation increases amplifier gain.

4. AMPLITUDE SCALE. Selection of linear, logarithmic or power (square law) amplitude presentations is accomplished with this three position rotary switch.

In the LOGarithmic position, signals having a 40 DB (100:1) voltage ratio can be viewed on the screen. In this switch position, the LOG

DB calibrations on the left side of the screen are used. The top (1.0) horizontal screen calibration is 0 DB, the center (0.5) horizontal calibration is -20 DB and the second line from the bottom (0.1) is -40 DB.

In the LINear position, signals having a 20 DB (10:1) amplitude ratio can be viewed on the screen. In this switch position, the horizontal voltage calibration lines on the Indicator CRT screen are used. The linear scale is calibrated in ten divisions.

In the PWR (power) position, the pip height varies as the square of the signal voltage for an approximate range of 4:1. The PWR (power) position measures power ratio; that is, pip deflection is proportional to the square of the input voltage ratio. The PWR position is used primarily to measure or observe small differences between the level of signal peaks.

5. IF BANDWIDTH. The IF BANDWIDTH control is used to vary the i-f bandwidth of the 3rd (6.5 MC) i-f amplifier. Counterclockwise rotation decreases the bandwidth of the i-f section. It should be noted that as this control is adjusted, there will be some degree of change in the amplitude of the signal pip. The IF BANDWIDTH control is used to separate closely spaced signals, to improve the signal to noise ratio of low level signals, or to improve the definition and brightness of pulse displays.

6. SWEEP WIDTH RANGE-SWEEP WIDTH CONTInuous. This is a dual concentric control. The SWEEP WIDTH RANGE control is the outer knob. The SWEEP RANGE CONTInuous control is the inner knob.

(a) SWEEP WIDTH RANGE. This control is a two-position switch which provides a

choice of 0 to 5 MC sweep width (narrow) or 0 to 70 MC sweep width. The 0 to 5 MC sweep width is used primarily for signals below 350 MC and/or when greater stability of screen presentations is required.

(b) SWEEP WIDTH CONTInuous. This is a continuously variable control. The range covered by this control is dependent upon the setting of the SWEEP WIDTH RANGE control.

7. 0-5 MC and 0-70 MC (Sweep Width Continuous) screwdriver controls. These are maximum limit adjustments for the SWEEP WIDTH CONTInuous control. They operate only when the SWEEP WIDTH RANGE control is in the corresponding position. They are primarily maintenance controls and are not normally used in operation of the equipment.

8. CENTER FREQuency. This is a dual control for centering both the wide and narrow sweep circuits. It operates in both the 0 - 5 MC and 0 - 70 MC positions of the SWEEP WIDTH RANGE control.

9. 70 MC and 5 MC (CENTER FREQuency) screw-driver controls. These act as coarse frequency adjustments. They are adjusted only when the SWEEP WIDTH RANGE switch is in the corresponding position. They also have an effect on linearity at the maximum setting of the SWEEP WIDTH CONTInuous control.

10. VIDEO FILTER. This three-position rotary switch provides two degrees of video filtering to suppress such unwanted effects as noise, spurious beating between adjacent signals, etc. The signal pips will be integrated and shifted slightly when the filter is in LOW or HI positions. An OUT position is provided.

11. LINE SIZE. A screw-driver control for adjusting horizontal baseline size.

12. Horizontal POS. A screw-driver control for shifting the baseline in a horizontal direction.

13. ASTIGmatism. A screw-driver control used to provide uniform focus of the CRT display.

14. Vertical POSition. A screw-driver control for shifting the baseline up or down.

15. SCALE ILLUMination. This is a rheostat and on-off switch mounted on the same shaft. It serves to dim or brighten the dial lamps that produce edge-lighting for the CRT screen. When the knob is turned counterclockwise it will dim the lights; fully counterclockwise will turn the illumination OFF.

16. MARKER LEVEL and ON Pilot Light. When the control knob is turned in the counter-

clockwise direction, the marker pip is attenuated. Approximately five complete revolutions are required to cover the range from minimum to maximum attenuation. When full maximum attenuation (counterclockwise rotation) is reached, a micro-switch is actuated and turns off the marker and the marker ON pilot light.

17. MARKER: 70 MC RANGE and 5 MC RANGE. The marker oscillator circuit is tuned by means of these controls. The 70 MC RANGE control has a range of ± 40 MC from "0" position. The 5 MC RANGE control is vernier which adds +3 MC to the 70 MC RANGE control.

18. FOCUS. The sharpness of the CRT display is adjusted with this control.

19. BRILLIANCE. The intensity of the CRT display is varied with this control. Clockwise rotation increases the brilliance.

20. INTENSIFIER. To observe pulsed or noise signals, this control is turned in a clockwise direction. Noise and pulse signals will then modulate the CRT beam. Normally, when using this control, the BRILLIANCE control is adjusted so that the baseline just disappears. Intensity modulation then causes the signals to appear on the screen.

I-8. TUBE COMPLEMENT

a. COMPOSITE TUNING HEAD, MODEL RF-4a.

Circuit Ref	Symbol	Type	Function
V301	6AF4A		Local Oscillator, 10 - 1000 MC
V302	6BM6		Local Oscillator, 910 - 4560 MC
V304	5721		Local Oscillator, 4.5 - 44 KMC
CR301	10LF		DC Heater Supply for V302
CR303	10LF		DC Heater Supply for V302
CR305	10Z6.3		DC Heater Supply for V302
CR307	10LF		DC Heater Supply for V304
CR309	10LF		DC Heater Supply for V304
CR311	10Z6.3		DC Heater Supply for V304
CR313	1N358A		10 - 11,000 MC Mixer
CR315	1N26		11 - 18 KMC Mixer
CR317	1N78		18 - 26.5 KMC Mixer

continued

<u>Circuit Ref Symbol</u>	<u>Type</u>	<u>Function</u>	<u>Circuit Ref Symbol</u>	<u>Type</u>	<u>Function</u>
CR319	1N53	26.5 - 44 KMC Mixer	V1009	6AB4	Pulse Detector
V401	5842	Preamplifier - 2nd stage	V1101	6CB6A	Cathode Follower
V402	5842	Preamplifier - 1st stage	V1102	6AB4	1st 6.5 MC i-f Amplifier
b. INDICATOR UNIT, MODEL I-4a			V1103	6CB6A	1st 6.5 MC Phase Splitter
<u>Circuit Ref Symbol</u>	<u>Type</u>	<u>Function</u>	V1104	6AB4	2nd 6.5 MC i-f Amplifier
V405	5842	Pentode 2nd distributed amplifier	V1105	6CB6A	2nd 6.5 MC Phase Splitter
V406	5842		V1106	6AH6	3rd 6.5 MC i-f Amplifier
V601	6AQ5	Wide-Band Osc. Driver	V1107	6AL5	Amplitude Scale Amplifier
V603	6AF4A	Wide-Band Oscillator	V1201	12AY7	Detector
V604	6AF4A	Wide-Band Mixer	V1202	12AU7A	Vertical Amplifier
V605	6AQ5	Wide-Band Oscillator Control Tube	V1203	6CB6A	Astig-Intensifier Amplifier
V606	12AX7	Wide-Band Oscillator Control Amplifier	V1301	12AT7	Blanking Amplifier
V701	6J6	Marker Oscillator	V1302	6CB6A	Sync Amplifier
V702	12AU7	Marker Modulator	V1303	6AB4	Sawtooth Generator
V801	6922	Narrow-Band Cascode Amplifier	V1304	12AU7A	Sawtooth Generator Cathode Follower
V802	6688	Narrow-Band Pentode Amplifier	V1401	5ADP1 or 5ADP7	Horizontal Amplifier
V803	6688	Narrow-Band Pentode Amplifier	c. POWER SUPPLY.		
V804	6J4	Narrow-Band Mixer	<u>Circuit Ref Symbol</u>	<u>Type</u>	<u>Function</u>
V805	12AT7	Narrow-Band Oscillator & Sawtooth Cathode Follower	V101	5R4GYA	Klystron Power Rectifier
V806	6CB6A	Reactance Tube	V102	5R4GYA	Klystron Power Rectifier
V1001	6CB6A	75 MC i-f Amplifier	V103	6146	Klystron Power Voltage Regulator
V1002	6CB6A	75 MC i-f Amplifier	V104	6146	Klystron Power Voltage Regulator
V1003	6CB6A	75 MC i-f Amplifier	V105	12AT7	Klystron Power Control Voltage Amplifier
V1004	6CB6A	75 MC i-f Amplifier	V106	OA2	Klystron Power Reference Tube
V1005	6AL5	Pulse Detector	V107	OG3	Klystron Power Reference Tube
V1006	6BA7	75 - 6.5 MC Mixer	V108	OA2	Klystron Power Voltage Regulator
V1007	12AT7	68.5 MC Oscillator			
V1008	6AH6	Pulse Detector Amplifier			

<u>Circuit Ref Symbol</u>	<u>Type</u>	<u>Function</u>
V109	OA2	Klystron Power Voltage Regulator
V110	OA2	Klystron Power Voltage Regulator
V111	OA2	Klystron Power Voltage Regulator
V112	6AS7GA	+300 Volt Supply Voltage Regulator
V113	6AS7GA	+300 Volt Supply Voltage Regulator
V114	12AX7	+300 Volt Control Voltage Amplifier
V115	12AX7	+300 Volt Control Voltage Amplifier
V116	6AS7GA	+200 Volt Supply Voltage Regulator
V117	12AX7	+200 Volt Control Voltage Amplifier
V118	12AX7	+200 Volt Control Voltage Amplifier
V119	OA2	-90 Volt Supply Voltage Regulator
V120	5651	-90 Volt Supply Voltage Regulator
V121	6AR6	CRT Power Oscillator
V122	1X2A/B	CRT Power Rectifier
V123	1X2A/B	CRT Power Rectifier
CR101 (4)	1N1084	+300 Volt Supply Bridge Rectifier
CR103 (4)	1N1084	+200 Volt Supply Bridge Rectifier
CR105 (4)	1N1084	-90 Volt Supply Bridge Rectifier
CR107	1N1450	-12 Volt Supply Rectifier
CR109	1N1450	-12 Volt Supply Rectifier
CR111	1N1605	-12 Volt Supply Rectifier
CR113	1N1605	-12 Volt Supply Rectifier
K101	GHP/3C/115 VAC	5-second Thermal Delay Relay
K103	115N060T	60-second Thermal Delay Relay

I-9. TERMS AND DEFINITIONS

a. PANORAMIC RECEPTION permits continuous visual observation on a CRT screen of the presence and relative strength of all signals within a wide frequency range above and below the frequency to which the analyzer may be tuned.

When used in communications it permits monitoring a wide band, and quickly indicates the frequency location of any type of signal and permits the interpretation of its characteristics. It also indicates the presence of open channels, for a quick selection of transmitting frequencies.

When used in laboratory work it facilitates the diagnosis of any waveform and speeds up verification of laboratory problems.

b. SWEEP WIDTH is the band, measured in cycles, kilocycles or megacycles, which can be observed by Panoramic reception and which corresponds to the range of oscillator sweep in the Panoramic equipment (A synonym for "dispersion")

c. BASELINE is the horizontal line swept across the cathode-ray tube by the electron beam whose motion is controlled by the sawtooth generator and its associated amplifiers.

d. FREQUENCY SWEEP AXIS is the line along which the signal deflections are produced and which can be calibrated in frequency according to a given frequency scale (a synonym for "baseline").

e. CENTER FREQUENCY is the frequency of the signal received on that part of the frequency sweep axis corresponding to zero sweep voltage applied to the reactance modulator.

f. RESOLUTION of a given signal is the frequency difference, measured along the frequency sweep axis between the points where its deflection is 30% down from the peak value. This characteristic corresponds to "selectivity" in ordinary receivers. The smaller this frequency difference, the better the resolution.

g. SWEEP RATE is the number of times per second the electron beam sweeps across the cathode-ray tube (sometimes called "sweep frequency").

h. DEFLECTION AMPLITUDE is the visual equivalent of signal input voltage. It is the height of a given signal deflection measured from the baseline to the top of the deflection.

i. SWEEPER is the reactance modulated oscillator used to heterodyne with the input signal in the mixer circuit to obtain the Panoramic reception described above.

j. MARKERS are the calibrated beat oscillations injected into the 1st i-f amplifiers used to locate a signal in the frequency spectrum.

k. LINE SIZE denotes the horizontal distance covered by the baseline.

l. CRYSTAL BIAS is the biasing current applied to the crystal mixers to position them on a linear portion of their current curve in order to obtain greater sensitivity and distortion-free operation.

CHAPTER II INSTALLATION

II-1. INITIAL INSPECTION

This instrument has been tested and calibrated before shipment. Only minor preparations are required to put the instrument in operation.

If damage to the case is evident when delivery is made, have the person making the delivery describe the damage and sign the notation on all copies of the delivery receipt. Most public carriers do not recognize claims for concealed damage if such damage is not reported within 15 days after delivery. All shipping containers should be opened and the equipment inspected before 15 days elapse. If damage is found, whether concealed or obvious when delivered, call or write the carrier and ask that an inspection be made by their agent.

Although the carrier is liable for any damage in shipment, Singer Metrics Division, The Singer Manufacturing Company, will assist in describing and providing for repair or replacement of damaged items.

The equipment is shipped with all tubes and crystals installed.

II-2. INTERCONNECTING PROCEDURE

a. **THE POWER SUPPLY** of the Spectrum Analyzer is factory wired for 115-volt, 50-60 cycle operation. The equipment is convertible to 230-volt, 50-60 operation by rewiring the power transformer primary connections. Refer to Figure II-4 for the proper connections to be made.

b. **CABLES.** The equipment is supplied with a power line cord which should be connected from a suitable source of AC power to the power receptacle located in the rear panel of the equipment. All other cables necessary for the operation of the equipment are located inside the cabinet and are connected at the factory before shipment.

c. **VENTILATION.** For adequate cooling, a 7-inch clearance must be allowed behind the unit, otherwise restricted air flow may cause overheating.

II-3. INSTALLATION ADJUSTMENTS AND CHECKS, INDICATOR UNIT, MODEL I-4a

a. Turn on the AC power with the POWER switch. The POWER pilot light should go on at once. Clockwise rotation of the SCALE ILLUMINATION

control should increase the illumination of the CRT screen edge-lighting. Set the GAIN control fully counterclockwise. Set the BRILLIANCE control to two-thirds of maximum clockwise position. Within thirty seconds the baseline trace should appear.

b. **FOCUS.** Turn this control through its range. The trace should change from blurred to sharp to blurred. Return the control to the position which gives the sharpest trace.

c. **BRILLIANCE.** Turn this control through its range. The intensity should vary; at full counterclockwise position, the baseline will be off; at full clockwise position, the baseline will be at its brightest. Focus may also vary. This is normal. Return to the control position giving a sharp bright trace.

d. **SWEEP RATE AND SYNC AMPL.** Set the CAL-SYNC SEL control to CAL. Turn the SYNC AMPL control fully counterclockwise and the SWEEP RATE control fully clockwise. Slowly rotate the SWEEP RATE control in a counterclockwise direction until a single sine wave indicating one cycle of the line frequency appears. The presentation should be almost stationary, with a slight drift to the left. Slowly turn the SYNC AMPL control until the presentation becomes steady. Further rotation of the SYNC AMPL control will tend to shorten the length of the baseline trace. The best setting of the SYNC AMPL control is the minimum sync amplitude consistent with a stationary display. The one cycle presentation indicates a 60 cps sweep rate.

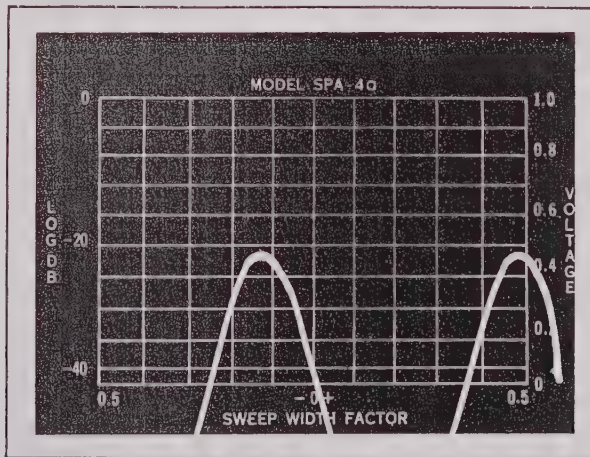


Figure II-1. Screen Presentation for 30-CPS Sweep Rate.

Continue as described above, and indications of 30 cps sweep (2 cycle presentation), 20 cps sweep (3 cycle presentation) and 15 cps sweep (4 cycle presentation) should appear. Figure II-1 is a photograph of a typical screen presentation showing two cycles of line frequency, indicating a sweep rate of 30 cps. (25 cps for a 50 cps power line frequency).

The sweep rate at any position is equal to 60 CPS divided by the number of cycles visible. At low rates it is easier to count sweeps, using a stop watch, than to count cycles. A 1-second sweep should be reached just before the maximum counterclockwise position of the SWEEP RATE control.

e. For the following checks, set the front panel controls to the general starting positions listed below.

Control	Setting
SWEEP WIDTH RANGE	0-70 MC
SWEEP WIDTH CONT	Fully clockwise
IF BANDWIDTH	Fully clockwise
BRILLIANCE	Desired trace brightness
INTENSIFIER	Fully counterclockwise
FOCUS	Sharp trace
CENTER FREQ	Center
AMPLITUDE SCALE	LIN
GAIN	Fully counterclockwise
CAL-SYNC SEL	LINE
SWEEP RATE	60 CPS
SYNC AMPL	To lock sweep
VIDEO FILTER	OUT
MARKER - 70 MC RANGE	0
5 MC RANGE	0
MARKER LEVEL	Fully counterclockwise
RANGE	Range 1
METER FUNCTION	CRYSTAL BIAS
TUNING MEGACYCLES	400 on Tuning Scale
RF ATTENUATOR	0

f. GAIN. Clockwise rotation of this control will increase the gain of the amplifiers in the equipment. To check the operation of this control, turn the GAIN control slowly from fully counterclockwise to fully clockwise. The noise display should increase from zero to more than 1/2 scale deflection.

It is recommended that for normal operation, the GAIN control be set to give 1/16 inch to 1/8 inch of noise when the IF BANDWIDTH control is in the fully clockwise position. The amplifier stages have an overall dynamic range of better than 40 db, consequently the operator can better judge whether his signal is distorted or not when

the GAIN control is so adjusted. (See paragraph h below).

g. MARKERS, SWEEP WIDTH and CENTER FREQ. Be sure that the equipment has had at least 15 minutes warm up before the following procedures are attempted.

1. Set the GAIN control for 1/8 inch of noise deflection.

2. Turn the MARKER LEVEL control clockwise until a full scale marker pip appears. The marker ON pilot light should glow.

- (a) Vary the 70 MC RANGE control between -35 and +35 on the MARKER dial. The marker pip should travel across the screen from the -0.5 calibration ($\pm 1/2$ screen division) to the +0.5 calibration ($\pm 1/2$ screen division).

- (b) Set the MARKER dial to 0. The marker pip should coincide with the center (-0+) screen calibration ($\pm 1/4$ screen division).

- (c) With the MARKER dial set at 0, rotate the SWEEP WIDTH CONTinuous control to zero sweep width (the fully counterclockwise position), keeping the marker pip centered with the 70 MC RANGE control. At zero sweep width the marker pip should appear as an elevated baseline.

- (d) Return the SWEEP WIDTH CONTinuous control to the fully clockwise position (maximum sweep width).

3. If any of the results indicated in paragraph 2 (a), (b), or (c) above are not obtained, adjust the (CENTER FREQUENCY) 70 MC and/or 0-70 MC (SWEEP WIDTH) screw-driver adjust controls to set up the correct -0+ center and ± 0.5 end limit marker pip positions. The (CENTER FREQUENCY) 70 MC screw driver control sets up the center screen marker pip position. The 0-70 MC (SWEEP WIDTH) screw driver control sets up the end limit marker pip positions. It may be necessary to work back and forth between both controls until the marker pip positions are within specifications.

4. Return both MARKER dials to 0.

5. Set the SWEEP WIDTH RANGE control to 0-5 MC. Adjust the GAIN control for 1/8 inch of noise deflection. Adjust the MARKER LEVEL control for a full scale marker pip.

6. Allow 2 minutes for the marker oscillator to stabilize.

- (a) Adjust the 70 MC RANGE control to bring the marker pip to the center of the screen.

(b) Vary the 5 MC RANGE control between -2.5 and +2.5 on the MARKER dial. The marker pip should travel across the screen from the -0.5 calibration ($\pm 1/2$ screen division) to the +0.5 calibration ($\pm 1/2$ screen division).

(c) Set the MARKER dial to 0 with the 5 MC RANGE control. Rotate the SWEEP WIDTH CONTInuous control to zero sweep width (the fully counterclockwise position), keeping the marker pip centered with the 5 MC RANGE control. At zero sweep width the marker pip should appear as an elevated baseline.

(d) Return the SWEEP WIDTH CONTInuous control to the fully clockwise position (maximum sweep width).

7. If any of the results indicated in paragraph 6 (b) (c) and (d) above are not obtained, adjust the 0-5 MC (SWEEP WIDTH) screw driver controls to set up the correct ± 0.5 end limit marker pip positions.

h. IF BANDWIDTH. With the marker pip centered, adjust the MARKER LEVEL control for full scale marker pip deflection. Set the SWEEP WIDTH CONTInuous control so that the pip width at 1/2 scale is approximately four screen divisions. Slowly turn the IF BANDWIDTH control in a counterclockwise direction. The pip width should decrease. At the same time there may be a change in pip height. Rotation through the full range of the IF BANDWIDTH control may result in a major change in pip height. It will also be noticed that small convolutions or "ringing" will appear on the trailing edge (left side) of the pip. Optimum resolution occurs when the first convolution beyond the apex of the pip dips into the baseline. (See Figure III-7d). Return the IF BANDWIDTH and SWEEP WIDTH CONTInuous controls to the fully clockwise position.

i. AMPLITUDE SCALE.

1. Set the front panel controls to the positions listed in paragraph e above.

2. Set the SWEEP WIDTH RANGE control to 0-5 MC.

3. Connect a 160 MC signal to the DIRECT (coaxial) INPUT connector. Tune the signal to appear at the left side of the baseline. The following measurements should fall within $\pm 5\%$ ($\pm 1/2$ div.) at the point under test.

4. Adjust the 160 MC generator for a 1000 microvolt output. Adjust the GAIN control to give a full scale pip. Reduce the generator output in 100 microvolt steps. Each change in input level should result in a pip height corresponding to the appropriate VOLTAGE (LIN) screen calibration on the right hand edge of the screen (0.9 for 900 microvolt input, 0.8 for 800 microvolt input etc.). (See Figure III-1 for correct viewing of CRT screen).

5. Switch the AMPLITUDE SCALE control to the LOGarithmic position. Adjust the generator for an output of -40 dbm. Adjust the GAIN control to give a full scale pip. Reduce the generator output to -60 dbm. The pip height should decrease to the -20 DB screen calibration (midscale). Reduce the generator output to -80 dbm. The pip height should decrease to the -40 DB screen calibration (next to the bottom line).

6. Switch the AMPLITUDE SCALE control to the PWR position. Adjust the generator output for a 1000 microvolt output. Adjust the GAIN control to give a full scale pip. Reduce the generator output to 700 microvolts. The pip height should drop down to approximately midscale.

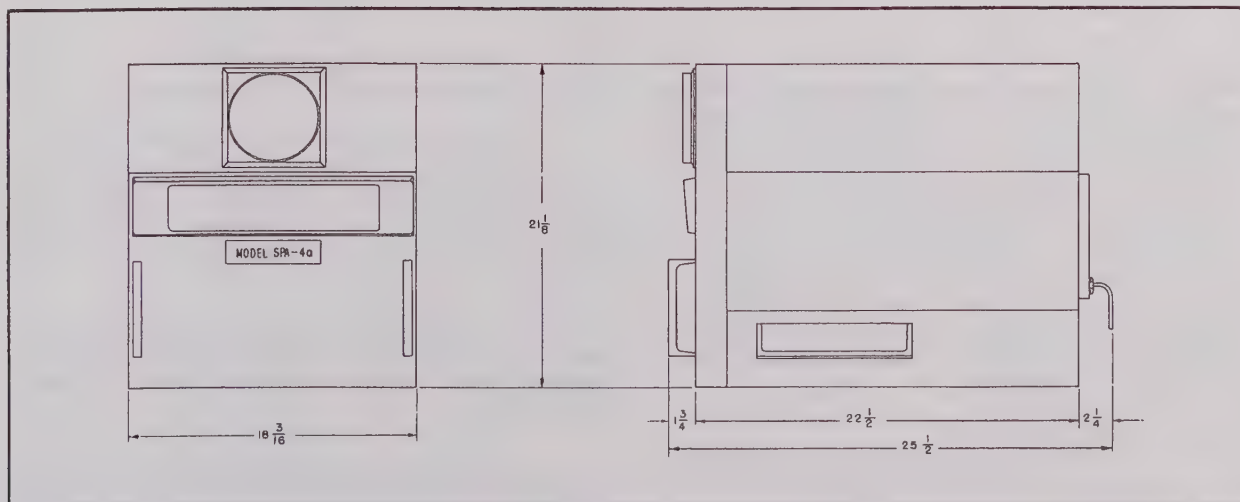


Figure II-2. Outline Dimensional Drawing, Model SPA-4a, in Cabinet.

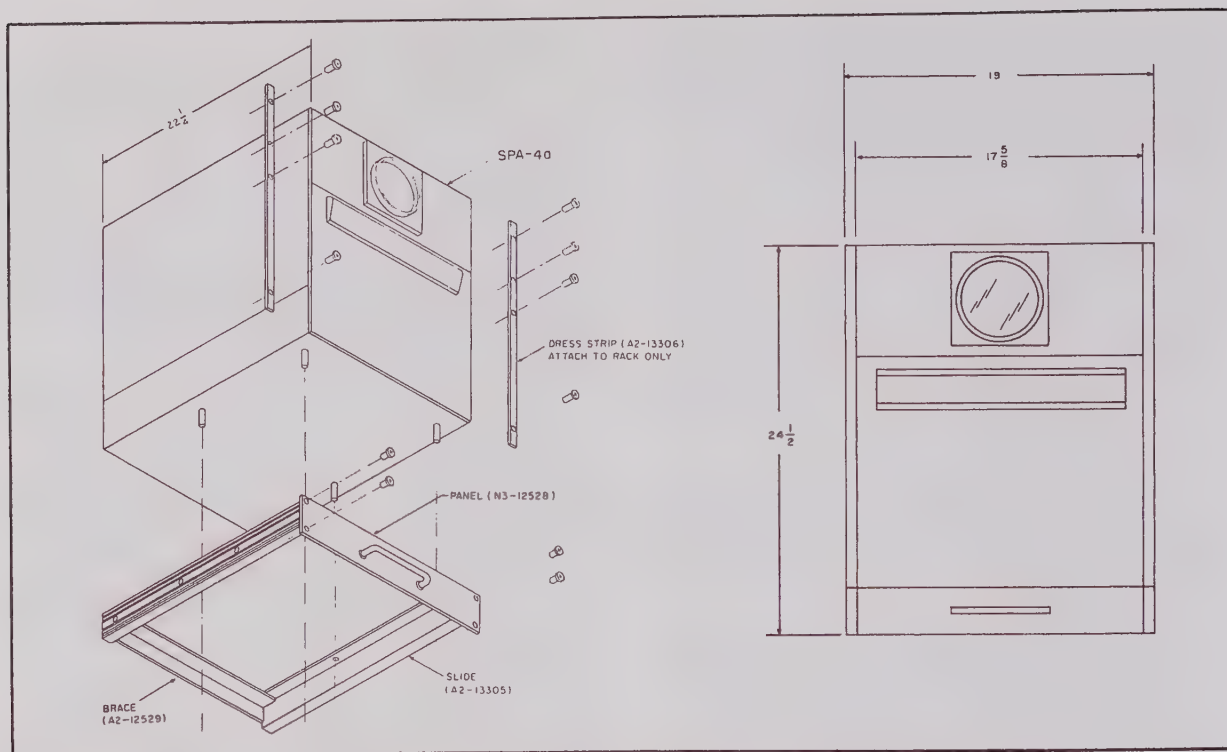


Figure II-3. Outline Dimensional Drawing, Model SPA-4aR Rack Mount Style.

j. VIDEO FILTER.

1. Set the front panel controls to the positions listed in paragraph e above.

2. Set the SWEEP WIDTH RANGE control to 0-5 MC.

3. Adjust the GAIN control to give approximately 1/2 inch of noise on the baseline. Adjust the MARKER LEVEL control to give a half scale pip. If necessary center the pip with the 70 MC RANGE control.

4. Switch the VIDEO FILTER to the LOW position. The noise should be filtered, and the marker pip will be integrated and shifted slightly. A greater effect will be noted when the VIDEO FILTER is switched to the HI position. Return to the OUT position. In operation the position (LOW or HI) of the VIDEO FILTER should be selected to give the clearest picture with minimum loss of amplitude. The sweep rate will have some effect on the resultant presentation; the slower the sweep rate, the better the presentation. Faster sweep rates will degrade the presentation beyond use.

k. CAL-SYNC SEL(ector)

1. For the CALibration position see paragraph d above.

2. EXTERNAL SYNCHRONIZATION position.

- (a) Set the front panel controls to the positions listed in paragraph e above.

- (b) Set the SWEEP WIDTH RANGE control to 0-5 MC. Set the GAIN control for approximately 1/8 inch of noise on the baseline.

- (c) Set the CALibration-SYNCHRONization SELector to EXTERNAL. Set the SYNCHRONIZATION AMPLitude control fully counterclockwise.

- (d) Rotate the MARKER LEVEL control clockwise to give a full scale marker pip.

- (e) Reduce the sweepwidth to zero by turning the SWEEP WIDTH CONTinuous control fully counterclockwise. Keep the marker pip centered with the 70 MC RANGE control. At this point the marker pip appears as an elevated baseline.

- (f) Connect a .5 v to 1 v, 1 KC signal to the MARKER MOD connector. A sine wave presentation, which drifts to one side, should appear on the screen.

- (g) Connect a cable from the same signal source which is connected to the MARKER MOD input to the EXT SYNC connector.

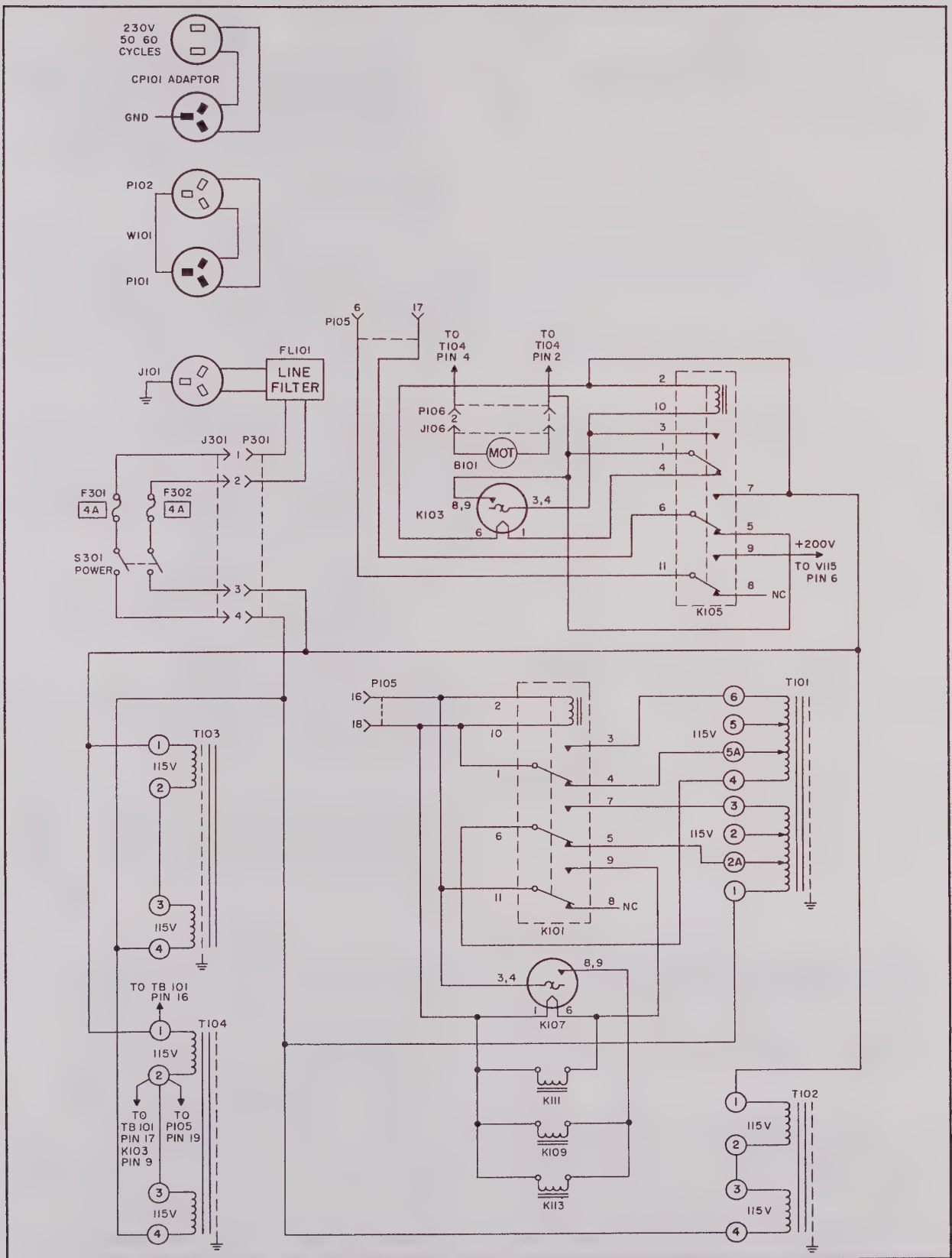


Figure II-4. Power Supply Conversion - 115 volt, 50-60 cps to 230 volt cps power line input.

(h) Rotate the SYNC AMPLitude control clockwise until the display on the CRT screen stops drifting and "locks in."

(i) Disconnect the input signals.

i. INTENSIFIER.

1. Set the front panel controls to the positions listed in paragraph e above.

2. Adjust the GAIN control to give approximately 1/8 inch of noise on the baseline.

3. Adjust the MARKER LEVEL control for a full scale pip.

4. Rotate the BRILLIANCE control counter-clockwise until the baseline just disappears.

5. Rotate the INTENSIFIER control clockwise until the marker pip appears. At this point the marker pip should be easily discernable although the baseline may not be visible. Note that this check should be performed under conditions where the ambient light is not too bright and where direct light is not allowed to fall on the Indicator CRT screen.

m. FRONT PANEL SCREW-DRIVER ADJUST CONTROLS.

The following screw-driver adjust controls are not used during the course of normal operation. They may require occasional adjustment to set up proper CRT presentations.

1. ASTIGMATISM. As brightness of the trace is varied, it may become difficult to focus the trace throughout its length. The ASTIGMATISM control should be adjusted to provide best over-all focus.

2. H(orizontal) POS(ition).

NOTE

This control should be left at the original factory setting unless adjustments are found to be necessary during alignment procedures. Adjustment by operating personnel may result in displacement of the display with respect to screen calibrations.

The baseline may be moved horizontally by means of the control marked H POS. Signals which are depicted as pips on the baseline will move with the baseline and so their relative positions to each other in the spectrum will not change. It is possible to move the baseline horizontally for a distance of approximately 2 divisions of the scale either way as marked in the screen.

3. V(ertical) POS(ition).

NOTE

This control should be left at the original factory setting unless adjustments are found to be necessary during alignment procedures. Adjustment by operating personnel may result in displacement of the display with respect to screen calibrations.

The baseline may be moved vertically by means of the control marked V POS. The relative heights of the signals depicted on the baseline will not change as the baseline is raised or lowered. It is possible to move the baseline up or down for a distance of approximately 1-1/2 inches.

4. LINE SIZE. The horizontal length of the trace is adjusted with the LINE SIZE control. If the trace is excessively long, resolution will be adversely affected; if the trace is too short, the scanning width will be reduced. Factory adjustment of this control normally provides a baseline which extends approximately 1/4 inch beyond the frequency scale extremities.

II-4. INSTALLATION ADJUSTMENTS AND CHECKS, COMPOSITE TUNING HEAD, MODEL RF-4a

The adjustments and checks given in this section assume that the Installation Adjustments and Checks of the Indicator Unit, Model I-4a, have been performed and that the Model I-4a is operating correctly.

a. TUNING. Rotate the TUNING knob through its range. The Tuning Scale pointer should travel from slightly beyond one end of the MEGACYCLES scale to slightly beyond the other end. The knob should operate smoothly throughout its rotational range.

NOTE

With a center frequency of 70 MC or below (Tuning Scale at 70 MC or less) and a sweep width of 70 MC (SWEEP WIDTH RANGE set to 0-70 MC) spurious signals will appear on the Indicator screen. This is normal. Below 70 MC only the 0-5 MC SWEEP WIDTH RANGE should be used. (Ref. par. III-2a.).

b. RF ATTEN, DB. Rotate the dial knob back and forth through its range. It should stop at 0 and turn slightly past 100 at the opposite end.

c. RANGE. Table I-1 gives the indications to be observed for each range of operation.

NOTE

A 1-minute delay occurs, starting from the time the POWER switch is turned ON. This delay is independent of range switching. When a range button is pushed, indicator lamps will light and the meter

should read as listed in Table II-1, Lamp and Meter indications.

d. As a further operational check that the local oscillators and mixers in the Tuning Head are operating properly, refer to paragraph III-1 for appropriate operating techniques.

TABLE II-1. LAMP AND METER INDICATIONS

Range	Dial Scale	Input Lamp	Local Osc. Lamp	Klystron Current	Cathode Volts	Repeller Volts
1	10 MC - 420 MC	10 MC - 1 KMC	ON	0	0	0
2	350 MC - 1000 MC	10 MC - 1 KMC	ON	0	0	0
3	910 MC - 2200 MC	1-11 KMC	ON (5 Sec. delay)	approx. 1/2 scale	1/2 scale	1/2 scale
4	1980 MC - 4560 MC	1-11 KMC	ON (5 Sec. delay)	approx. 1/2 scale	1/2 scale	1/2 scale
5	4500 MC - 10880 MC	1-11 KMC	ON	approx. 1/2 scale	1/2 scale	1/2 scale
6	10880 MC - 18000 MC	11-18 KMC	ON	approx. 1/2 scale	1/2 scale	1/2 scale
7	18000 MC - 26400 MC	18-26.5 KMC	ON	approx. 1/2 scale	1/2 scale	1/2 scale
8	26400 MC - 44000 MC	26.5 - 44 KMC	ON	approx. 1/2 scale	1/2 scale	1/2 scale

Notes:

1. +300 V and +200 V should read half-scale in all ranges.
2. CRYSTAL BIAS will read up to a maximum of full scale, depending upon the range in use.

CHAPTER III OPERATION

III-1. GENERAL OPERATION

a. GENERAL

The Panoramic Spectrum Analyzer, Model SPA-4a, is a narrow-band superheterodyne receiver-indicator which is divided physically into two major components; the Indicator, Model I-4a, and the Composite Tuning Head, Model RF-4a.

The Indicator, Model I-4a, is a complete spectrum analyzer with a frequency range of 125 to 195 megacycles. The input center frequency of the Indicator is 160 megacycles.

The Composite Tuning Head, Model RF-4a is basically a frequency converter which heterodynes signals in the 10 to 44,000 megacycle range to the 125 to 195 megacycle input range required for display on the Indicator CRT.

As the SPA-4a is tuned through its ranges from the low to high ends of the scale, the signals travel across the screen from right to left. They appear as pips of varying amplitudes. The pip directly over the center -0+ CRT screen calibration line represents the signal to which the RF input is tuned. Because the RF input has no preselection and is extremely broadband, undesired images and harmonics may appear upon the screen. The information contained in paragraph III-2,b will aid the operator in determining which are true signals and which are images or harmonics.

Refer to paragraph I-7 for operation of front panel controls.

Refer to paragraph III-5 for information on interpretation of signal displays.

b. INITIAL SETTING OF CONTROLS.

Turn on the AC power with the POWER switch. The baseline will appear within thirty seconds. Set the front panel controls to the general starting positions given below. (For best stability, a 15 to 30 minute warm-up period is recommended before operating equipment.)

CONTROL	SETTING
CENTER FREQ.....	Center
SWEEP WIDTH RANGE.....	0 - 70 MC. When Tuning Scale

CONTROL	SETTING
	is set below a center frequency of 70 MC always use 0 - 5 MC Sweep Width Range
SWEEP WIDTH CONT.....	Fully clockwise
IF BANDWIDTH.....	Fully clockwise
BRILLIANCE.....	For desired trace brightness
INTENSIFIER.....	Fully counter-clockwise
FOCUS.....	Sharp trace
ASTIG.....	For uniform focus
AMPLITUDE SCALE.....	LIN
GAIN.....	1/16" of noise deflection
CAL-SYNC SEL.....	LINE*
SWEEP RATE.....	Line frequency (50 or 60 CPS) *
SYNC AMPL.....	Approx 1/4 clockwise (to lock in sweep) *
VIDEO FILTER.....	OUT
MARKER.....	70 MC RANGE to '0' 5 MC RANGE to '0'
MARKER LEVEL.....	Clockwise to give 1-inch marker pip
RANGE.....	To desired range
INPUT.....	Use appropriate receptacle to connect signal source or antenna lead (Refer to paragraph I-7. a.7. for limitations and procedures.)
METER FUNCTION.....	Any
TUNING MEGACYCLES.....	Set the Tuning Scale pointer to the frequency of the signal of interest. If the signal frequency is unknown, or a search for unknown signals is being made, refer to para-

graph III-2.b. for appropriate operating techniques.

* See paragraph II-3.d for a description of proper operation of these controls.

NOTE

When viewing the CRT screen, the operator should keep his sight directly in line with the axis of the cathode-ray tube at a distance approximately fifteen inches. The screen calibrations have been made from this position, any other position will introduce parallax error. A convenient method of finding the correct position is to close one eye and obtain a reflection of the open eye at the exact center of the engraved scale. Correct viewing position is illustrated in Figure III-1.

c. LOCATING A SIGNAL OF KNOWN FREQUENCY.

If the specific frequency range of interest is known, set up the Spectrum Analyzer as outlined in paragraph b. above. Set the Tuning Scale pointer to the point where such signals may be expected to appear. Slowly search this portion of the spectrum until the signals of interest appear on the screen. The Tuning Scale is calibrated in terms of the frequency of the signal at the center -0+ calibration on the CRT scale.

NOTE

In the 1 to 4.5 KMC band (RANGE 4/3) and the 4.5 to 11 KMC band (RANGE 5) the repeller mode of the klystron local

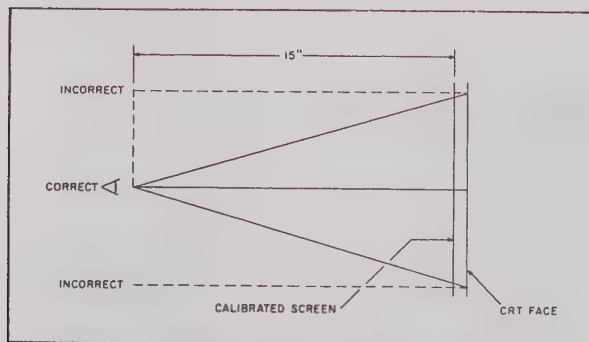


Figure III-1. Correct Viewing of CRT Screen.

oscillator is switched in about the middle of the scale. A momentary transient signal may appear on the screen in ranges 3 through 8. This is normal and should not be interpreted as a signal.

d. HOW TO READ THE TUNING SCALE.

When a RANGE button is pressed, the portion of the Tuning Scale which is put into operation is illuminated. Within this illuminated area, the pointer will indicate the exact frequency (within $\pm 1\%$ or ± 2 MC, whichever is greater) of the signal appearing at the center -0+ calibration line of the CRT scale.

RANGE button 2/1 will put Ranges 1 and 2 into operation. RANGE button 4/3 will put Ranges 3 and 4 into operation. RANGE buttons 5, 6, 7 and 8 put Ranges 5, 6, 7 and 8 respectively into operation. Therefore, in Range 2/1 scales 1 and 2 will be illuminated, which means that a signal appearing at the center of the CRT screen is located in either Range 1 or Range 2. The illuminated scale to be used is determined by the frequency of the signal being examined.

NOTE

Tuning scale calibrations for Ranges 6, 7, and 8 have a wide overlap on each range. The specifications for sensitivity apply only to the portions of the Tuning Scale corresponding to the frequency range markings beside each RANGE button.

III-2. FREQUENCY DETERMINATION

a. SPURIOUS SOURCES.

Spurious responses of the Model SPA-4a may originate from many sources because of the basic design of the instrument, a superheterodyne receiver without pre-selection. Because of this, care must be taken that true signals are being displayed.

Spurious responses are of six general types as follows:

1. Intermediate-frequency feed-through at 160 MC ± 2.5 MC or ± 35 MC. This source is easily recognized. The resultant pip will not move on the CRT screen as the TUNING knob is rotated. The signal will behave like an injected marker signal. No harmonic or image response will be generated by this type of signal.

2. Local oscillator image or harmonic responses as described in paragraphs b, c and d below.

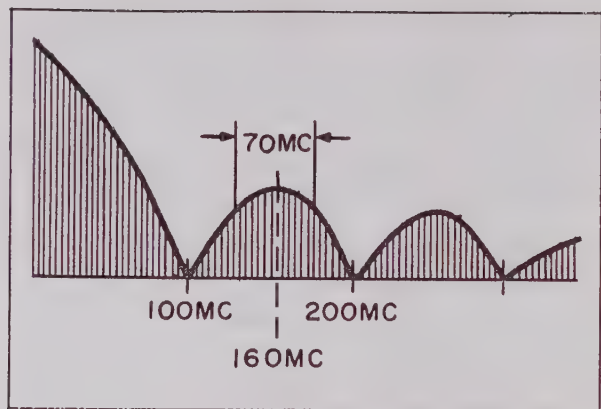


Figure III-2. Spectrum of .01 used Pulse.

3. Injecting signals with amplitudes greater than -40 dbm may result in the generation of spurious signals. The -40 dbm limitation applies both to signals displayed on the screen and to signals outside the spectrum segment to which the unit is tuned. For example, injecting a -10 dbm signal at 100 MC may cause harmonics of 100 MC to be generated in the input mixer, producing a spurious signal pip at 2000 MCS.

4. Spurious in-band signals may be generated in the i-f amplifiers when the signal pip on the screen is allowed to go over full scale due to an incorrect setting of the GAIN control.

5. Spurious signals will be seen on the CRT screen when the SWEEP WIDTH RANGE control is in the 0 - 70 MC position and the Tuning Scale pointer is set to a position below 100 MC. This is normal. To observe signals with a center frequency below 100 MC only the 0 - 5 MC sweep width range should be used.

6. Very narrow pulse signals (in the order of .01 μ sec) of high amplitude will produce a video pulse in the input mixer. The detected video pulse contains spectral energy which is accepted directly by the 160 MC i-f. Figure III-2 illustrates the spectrum of a .01 μ sec pulse.

Note that 70% of the second lobe falls within the i-f "acceptance slot" of the Indicator and would appear as a stationary display across the full width of the CRT screen.

b. IDENTIFICATION OF LOCAL OSCILLATOR IMAGE AND HARMONIC RESPONSES.

The origin and frequency of an unidentified pip are determined by means of the following procedure:

1. Adjust the SWEEP WIDTH CONTINUOUS control to display a 70 MC sweep width on the CRT screen as follows:

(a) Adjust the MARKER LEVEL control for a half to full scale pip.

(b) Set the MARKER dial to +35 by rotating the 70 MC RANGE control.

(c) Adjust the SWEEP WIDTH CONT control to place the marker pip at the +0.5 vertical screen calibration.

(d) Set the MARKER dial to -35 and check the position of the marker pip. The pip should be approximately at the -0.5 vertical screen calibration.

2. Rotate the TUNING MEGACYCLES knob to place the signal pip being investigated at the +0.5 CRT screen calibration. Note the frequency indicated by the Tuning Scale pointer. (In Ranges 1/2 and 3/4 the frequency indicated by the bottom scale should be used).

Rotate the TUNING MEGACYCLES knob to move the signal pip to the -0.5 CRT screen calibration. Note the frequency indicated by the Tuning Scale pointer. (In order to minimize error due to possible backlash, make both final settings by turning the TUNING knob in the same direction.

Calculate and record the difference between the two frequencies.

3. Calculate and record the order of the harmonic of the local oscillator producing the signal pip being investigated using equation (1).

$$n = \frac{\text{sweep width}}{f_{\text{diff}}} \quad n = 1, 2, 3 \dots$$

where: n = order of harmonic of local oscillator producing pip.

f_{diff} = difference in frequency between Tuning Dial settings.

Check whether the pip is a "true" (harmonic) or "image" type pip by comparing the direction of pip travel with respect to the direction of travel of the Tuning Scale pointer. If the pip moves in the same direction as the pointer, the pip is an image. If the pip moves in the direction opposite to dial pointer travel, the pip is a "true" type.

(4) (a). If the pip is a "true" type, calculate the frequency of the origin of the signal using equation (2).

$$f_x = nf_{\text{dial}} + (n-1) 160$$

where: f_x = frequency of the origin of the unknown signal in MC.

$$f_{\text{dial}} = \text{Tuning Dial reading when signal being investigated is at the center of CRT screen (} f_{\text{dial}} \text{ read on lower scale of double scales).} \quad (2)$$

n = order of harmonic of local oscillator producing pip.

(b) If the pip is an "image" type, calculate the frequency of the origin of the signal using equation (3).

$$f_x = n f_{\text{dial}} + (n+1) 160 \quad (3)$$

6. Set the Tuning Dial (and RANGE button if necessary) to the calculated signal frequency. The signal pip should appear on the CRT screen.

7. Recheck that the pip is a "true" type (pip travels direction OPPOSITE to pointer travel as TUNING knob is rotated) and that $n = 1$ (see equation (1)). In rechecking use the scale (upper or lower) containing the frequency calculated for f_x to check that $n = 1$. This is based upon the fact that the upper scale in Ranges 1/2 and 3/4 is based on the second harmonic of the local oscillator for that pair. The calibration of the scales for Ranges 6, 7 and 8 are based upon the second, third and fourth harmonics respectively of the Range 5 local oscillator.

8. Errors can occur in the foregoing method because of the rounding off of " n " to the nearest integer when " n " is a large number (4 or above). If a signal pip does not appear at the calculated place, or if a pip with an incorrect value of " n " appears, repeat and recheck the foregoing procedures. Also try values of " n " one below or one above the value originally calculated.

9. As a final check, an absorption type wavemeter can be used. The wavemeter is inserted between the signal source and the input as shown in Figure III-3.

The wavemeter will produce a slight dip in pip amplitude when it is tuned to the correct frequency. However, the procedure outlined in paragraphs 1 through 8 above should be com-

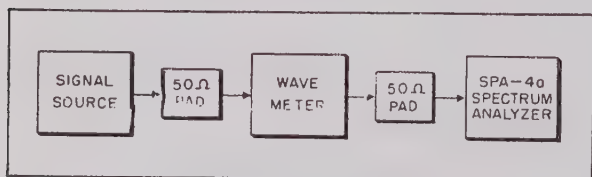


Figure III-3. Test Setup for Wavemeter Measurements.

pleted first. An attempt to use a wavemeter to measure signals outside its frequency range could produce spurious wavemeter responses which could lead to false conclusions regarding the frequency of the signals being investigated.

c. IDENTIFICATION OF FIRST MIXER HARMONICS OF THE SIGNAL.

Once it has been determined that the pip on the screen is caused by the fundamental (or correct harmonic) of the local oscillator, the possibility that the pip is some harmonic of a lower frequency signal can be checked. This harmonic can be caused by overload of the input mixer by the input signal or it can be a true component of the input signal. In either case the fundamental signal can be found by tuning to the various sub-harmonics (1/2, 1/3, 1/4, etc.) of the dial frequency and searching for signals.

If it is necessary to determine the source of the harmonic, any of the following procedures can be tried:

1. Insert a known large amount of attenuation between the signal source and the spectrum analyzer. Use an attenuator which operates in the frequency of both the fundamental and the harmonic. If the harmonic decreases as much as the fundamental, then the harmonic is a signal component. If the harmonic decreases at a much greater rate than the fundamental, the harmonic is produced in the input mixer of the analyzer.

2. A low pass filter can be inserted between the signal source and the spectrum analyzer. This would eliminate the fundamental but have negligible effect on the harmonic. Therefore, the harmonic is not eliminated it is a signal component; if the harmonic is eliminated it is created in the input mixer.

3. A wavemeter can be inserted in the signal path. If it produces a dip at the harmonic frequency, then the harmonic is a signal component. It is well to check that the wavemeter does not cause a dip at the fundamental frequency, when it is tuned to the harmonic.

d. EXAMPLE OF FREQUENCY DETERMINATION.

In searching for spurious signals from an oscillator, a pip is discovered at 350 MC (Range 1). The following steps are taken to determine the true signal frequency.

1. SWEEP WIDTH RANGE control set to 0 - 70 MC.

2. SWEEP WIDTH CONTinuous set for

a 70 MC sweep width, using marker pip to calibrate display.

3. The Tuning Scale pointer is moved by rotating the TUNING MEGACYCLES knob slightly and it is noted that the pip moves in the same direction as the Tuning Scale pointer. This indicates that the pip is caused by an image signal.

4. The pip is set to the +0.5 vertical screen calibration. The frequency indicated by the Tuning Scale pointer is 358 MC.

5. The pip is then moved to the -0.5 vertical screen calibration. The frequency indicated by the Tuning Scale pointer is 342 MC.

6. Using equation (1), n is determined to be:

$$n = \frac{70}{358-342} = \frac{70}{16} = 4.36 \approx 4$$

7. The "true" signal frequency is calculated using the "image" equation (3).

$$f_x = nf_{\text{dial}} + (n + 1) 160$$

$$f_x = 4(350) + 5(160) = 2200 \text{ MC}$$

8. The 3/4 RANGE button is depressed and the Tuning Scale pointer is set to 2200 MC on Range 4. A pip is discovered on the CRT screen.

9. When the TUNING MEGACYCLES knob is rotated slightly it is noted that the pip moves in a direction opposite to Tuning Scale pointer travel. This indicates that the pip is not produced by an image.

10. The pip is set to the -0.5 CRT screen calibration. The Range 4 Tuning Scale frequency is 2240 MC.

11. The pip is moved to the +0.5 CRT screen calibration. The Range 4 Tuning Scale frequency is 2165 MC.

12. Subtracting, $2240 - 2165 = 75 \text{ MC}$, which is close enough to 70 to show that 2200 MC is the correct signal.

13. Finally, solving equations (2) and (3) in reverse produces:

$$f_{\text{dial}} = \frac{f_x - (n + 1) 160}{n} = \frac{2200 - (n + 1) 160}{n}$$

Solving for f_{dial} the following tabulation is obtained.

n	Harmonic "True" pips	Harmonic "Image" pips
1	2200 MC	1880 MC
2	1020	860
3	627	520
4	430	350
5	312	248
6	233	180
7	177	131
8	154	95
9	102	66
10	76	44
11	54.5	22.5
12	36.6	10 MC
13	21.5 MC	

These signals will appear on Ranges 1, 2, 3 and 4. Unless the 2200 MC signal can be suppressed, pips which appear at all the points on the Tuning Scale listed above (except 2200 MC) should be disregarded in further search for additional signals.

Note that all the pips produced by the mixing of an input signal with harmonics of the local oscillator fall at points on the Tuning Scale below the true input frequency. For this reason it is good practice, when searching for unknown signals, to start at the highest frequency of interest and search downward in frequency.

e. FREQUENCY MEASUREMENTS TO AN ACCURACY OF 1%.

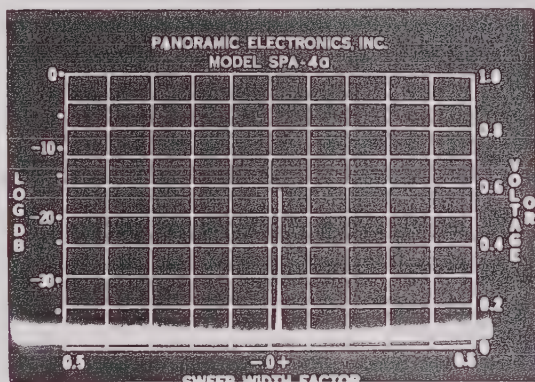
Once the approximate frequency of a signal is known and it is required to measure the frequency to the 1% accuracy of the Model SPA-4a, the following procedure is used.

1. Adjust the SWEEP WIDTH CONTINUOUS control for a sweep width of a few megacycles.

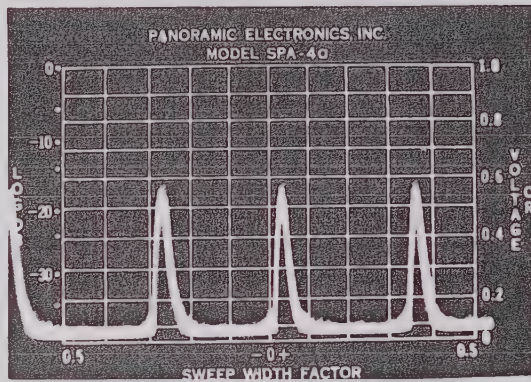
2. Set the 70 MC RANGE and 5 MC RANGE MARKER dials to 0.

3. Adjust the MARKER LEVEL control to produce a full scale marker pip.

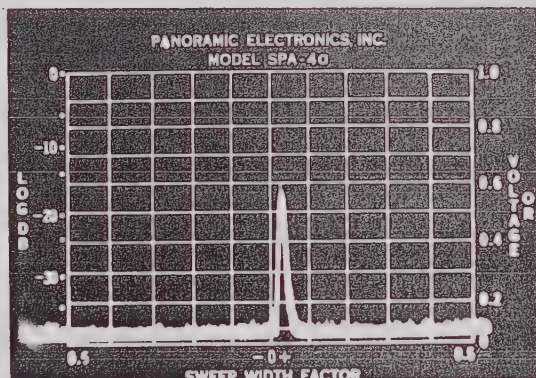
4. Adjust the TUNING MEGACYCLES knob until the signal pip coincides with the marker pip.



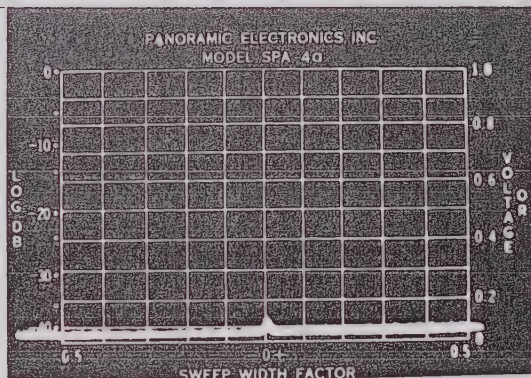
a



b



c



d

Figure III-4. Maximum Sensitivity Measurements.

5. Read the exact frequency on the Tuning Scale.

f. MAXIMUM SENSITIVITY MEASUREMENT.

1. In order to measure maximum equipment sensitivity use the following procedure:

(a) Using a calibrated signal generator, feed a CW test signal in the DIRECT INPUT jack. See figure III-4, a.

(b) Set the Indicator controls as follows:

SWEEP RATE 30 cps
synchronized
VIDEO FILTER OUT
AMPLITUDE SCALE LIN
SWEEP WIDTH RANGE 5 MC for band
1 and 2
70 MC for band
3 to 8.
SWEEP WIDTH CONT Half range
IF BANDWIDTH MAX (fully
clockwise)

GAIN For 1/2 scale
signal

MARKER Set to maximum
attenuation
(fully counter-
clockwise)

CENTER FREQUENCY Adjust signal pip
to center of
screen

(c) Reduce SWEEP WIDTH, continually optimizing resolution with the IF BANDWIDTH control until just before FM breakup occurs. See figure III-4, b for spectrum of FM breakup.

(d) Increase GAIN, if necessary, to keep the signal approximately half scale. Keep signal centered horizontally with the CENTER FREQUENCY control. See figure III-4, c.

(e) Set the GAIN control to obtain one vertical division of noise or to maximum setting if one division of noise cannot be obtained. Using the signal generator output attenuator, reduce the pip amplitude until signal + noise = twice noise.

See figure III-4, d. Note that the criterion used in determining maximum sensitivity is the signal to noise ratio. The total amount of noise present on the screen is irrelevant as long as the 2 to 1 ratio can be measured at the dated sensitivity or better.

(f) Read the signal strength on the signal generator. Maximum sensitivity ratings for all bands will be found in the equipment specifications. (Refer to paragraph I-5.)

g. RESPONSE OF A SPECTRUM ANALYZER TO PULSED R-F SIGNALS.

The response of a spectrum analyzer to pulsed r-f signals has been analyzed in detail by many groups. A detailed discussion is contained in the Radiation Laboratory Series, Volume 11, "Technique of Microwave Measurements", Chapter 7, entitled "The Measurement of Frequency Spectrum and Pulse Shape". The analysis deals with very short pulses ranging from 0.1 microsecond to several microseconds and with a relatively long time interval between pulses. In general, the i-f amplifier of the spectrum analyzer is narrow compared to the reciprocal of the pulse width but is still sufficiently broad so that the transient generated by a pulse has decayed entirely before the next pulse occurs.

The analysis shows that there is a loss in response of an analyzer between cw signals and pulsed signals due to the fact that the i-f bandwidth is narrow compared to the bandwidth necessary to transmit a pulse without distortion. The response of the analyzer to a pulsed signal is:

$$e = \frac{A \cdot 3 \tau (\Delta f)}{2}$$

where

A = response to a cw signal in volts
 τ = r-f pulse length (rectangular pulse)

Δf = 3 db down i-f bandwidth

e = voltage response to a pulse

In the case of a 0.1 microsecond pulse and a bandwidth of 80 KC

$$e = \frac{A(3) (.1 \times 10^{-6}) (80 \times 10^3)}{(2)} = .012A$$

This corresponds to a loss of approximately 38 db.

In addition, the noise is increased from that obtained when measuring the cw tangential sensitivity at a 1 KC bandwidth, due to the fact that we are now using the analyzer at an 80 KC i-f bandwidth. The increase in noise voltage is proportional to the square root of the bandwidth, or about 19 db additional noise. Therefore, the tangential sensitivity of the analyzer to a 0.1 microsecond pulse is: $-55 + (19 + 38)$ or $+2$ dbm. (The -55 dbm is the sensitivity to a cw signal at 1 KC bandwidth).

Any signal greater than approximately -10 dbm would overload and block the input crystal, causing the analyzer to be inoperative. This -10 dbm signal would therefore be 12 db below the noise.

For good spectrum analysis a signal to noise ratio of about 20 db is required. Therefore, with a -10 dbm input signal, to analyze a 0.1 microsecond pulse in the 34-36 KMC frequency range, an increase in sensitivity of about 32 db is required.

III-3. AMPLITUDE MEASUREMENTS

a. GENERAL.

The relative strengths of displayed signals are indicated by the respective heights of each pip. Selection of logarithmic, linear or power (square law) amplitude presentation is made with the AMPLITUDE SCALE switch.

1. In the LINEAR position of the AMPLITUDE SCALE switch the right hand (VOLTAGE) Indicator screen calibrations from 0 to 1.0, which correspond to the horizontal lines, are used. These are direct relative voltage calibrations. A signal at half scale (0.5 horizontal line) is one half the voltage (6 db down) of a signal at full scale (1.0 horizontal line).

2. In the LOGarithmic position of the AMPLITUDE SCALE switch the left hand (LOG DB) Indicator screen calibrations are used. The CRT screen is calibrated with dots along the left hand side in 5 db graduations. 0 DB corresponds to the top (1.0) horizontal line, -20 DB corresponds to the center (0.5) horizontal line and -40 DB corresponds to the 0.1 (next to the bottom) horizontal line. Thus the LOG position of the AMPLITUDE SCALE switch provides a three point calibration. A signal at half scale is 20 db down (1/10 in voltage, 1/100 in power) from a full scale signal.

3. In the PWR (Power) position of the AMPLITUDE SCALE switch the calibrations on the right hand side of the Indicator screen (0 to 1.0) are used but are read directly in power. A signal at half scale (0.5) is half power (3 db down, 70% in voltage) from a full scale signal.

b. FLATNESS.

In the Model SPA-4a flatness is defined as the

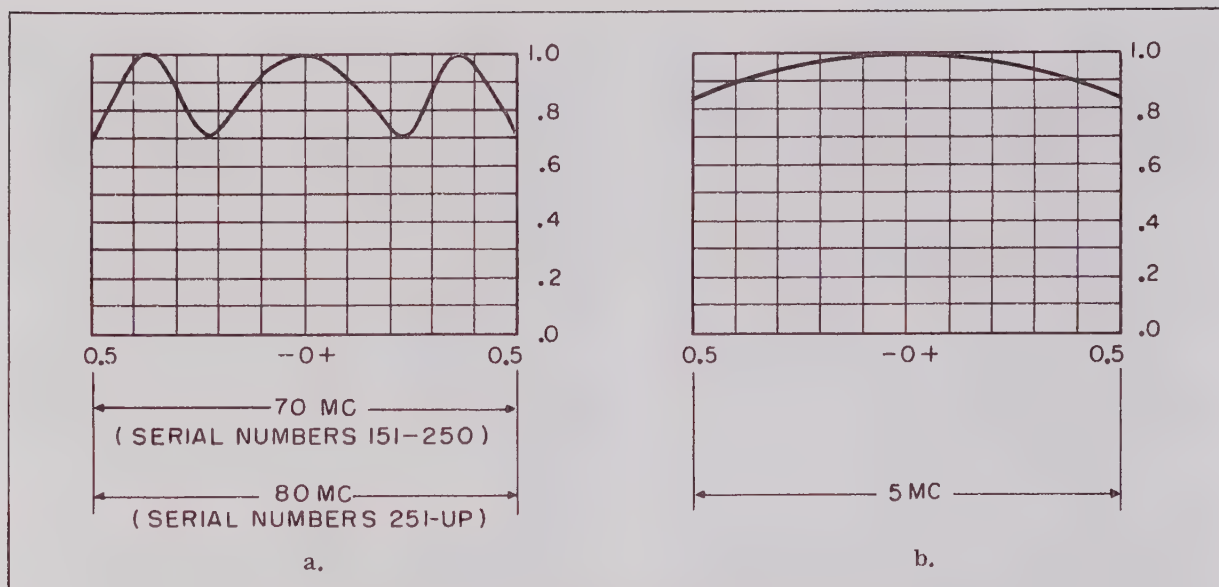


Figure III-5. Typical IF Flatness Curves, Model SPA-4a.

total variation in db of amplitude response of a signal pip as a signal input of constant amplitude is varied over a given frequency band. The overall flatness of the Model SPA-4a is the algebraic sum of the flatness of the first i-f amplifier bandpass (70 MC, (80 MC for serial nos. 251 and up) or 5 MC) plus the flatness of the Tuning Head input circuits. Typical i-f flatness curves are shown in Figure III-5 a and b.

IMPORTANT

When i-f flatness measurements are taken, a 3 db or 6 db pad should be connected to the DIRECT INPUT jack in series with the signal source to provide a termination for the r-f cable in use.

NOTE

I-f flatness will change somewhat with line voltage due to filament variation.

In general, because the response of the input circuitry is relatively flat over any selected 70 MC (80 MC for Serial numbers 251 and up) spectrum segment, the total response of the Model SPA-4a does not differ materially from the i-f response. Although the design specification of the SPA-4a i-f flatness is 3 db, the usual result is some what better than $\pm 1\frac{1}{2}$ over most of the r-f range. However, at a few discrete frequencies it is possible that, due to crystal resonance or mismatches, there will be a dip in the input section response, which combined with the i-f response, will yield a total flatness somewhat greater than 3 db.

c. MEASUREMENT OF RELATIVE AMPLITUDES OF DISCRETE SIGNALS OR SPECTRA WITH DISPERSIONS OF 70 MC OR LESS.

1. Connect the signals to the appropriate INPUT. Use RF padding if the input signal is of sufficient amplitude. Set the appropriate RANGE button and the TUNING MEGACYCLES knob to display the signals of interest on the Indicator screen.

2. Set the SWEEP WIDTH RANGE control to the required range. Use the SWEEP WIDTH CONTINUOUS control to set the minimum sweep width required to display the signals of interest.

3. Set the AMPLITUDE SCALE switch to the desired position.

4. If required, adjust the IF BANDWIDTH control for best resolution. (See paragraph I-7b for adjustment of this control).

5. Adjust the GAIN control so that the largest signal pip present on the Indicator screen is exactly full scale.

6. Read the relative amplitudes of the signal pips (within approximately 3 db flatness accuracy). At reduced sweep widths it is probable that the flatness will be better than 3 db.

7. For more accurate measurements it will be necessary to make a flatness curve for the frequency range of interest. The flatness curve is then used as a calibration chart.

(a) A rough flatness curve can be made

by rotating the TUNING MEGACYCLES knob to move the largest signal present back and forth across the full width of the Indicator screen. The top of the pip will trace the response curve across the top of the screen. Adjust the GAIN control so that the highest point traced by the top of the pip is at full scale. Using a grease pencil, mark the curve traced by the top of the pip while rotating the TUNING MEGACYCLES knob to sweep the signal back and forth across the Indicator screen.

(b) An accurate flatness curve can be marked on the Indicator screen by using an external signal generator. Connect a signal at the frequency of interest to the appropriate input, keeping the output level constant. Vary the frequency of the signal generator over the required range. If a long cable is normally used to connect signals being investigated to the Model SPA-4a, the same length of cable must be used to connect the signal generator being used for calibration.

d. MEASUREMENT OF ABSOLUTE AMPLITUDE.

1. Set the signal of interest to full scale at the center of the Indicator screen using the procedures outlined in paragraph c. (1 through 5 above.)

2. Remove the input signal. Without altering the settings of the Model SPA-4a controls, inject a signal of the same frequency from an external signal generator. Adjust the attenuator of the signal generator to provide a full scale pip at the center of the Indicator screen.

3. Read the absolute amplitude of the signal of interest on the attenuator of the signal generator.

4. Repeat steps 1, 2, and 3 for each signal of interest.

The i-f flatness response should not have more than 3 db deviation in amplitude across each 70 MC segment (80 MC for Serial nos. 251 and up) across the dial scale. The i-f response and mixer responses are checked separately.

A gradual change in amplitude is considered to be a change in sensitivity while an abrupt up and down change is considered to be a "hole".

If a "hole" greater than 6 db is encountered, it can be improved by proper matching of the r-f input connections and cabling.

Another method of improving mismatch is by adjusting the crystal bias voltage for that point.

CAUTION

This adjustment should be made only if extensive use of that particular r-f frequency point is to be made, because mismatch of other points may occur. Make a note of the exact crystal bias voltage as indicated on the front panel meter before making adjustments so that the original voltage may be restored at the completion of work.

e. RELATIVE MEASUREMENT OF SIGNALS WITH FREQUENCY SEPARATION GREATER THAN 70 MC.

1. Due to variation in flatness response of the Tuning Head, over any one frequency range or from one range to another, only absolute amplitude measurements of widely dispersed signals are possible. See paragraph III-3d above. True relative amplitude measurements can only be made when both signals are present on the Indicator screen at the same time.

f. SEARCH FOR LOW LEVEL SIGNALS.

1. Detection of low level signals involves a compromise between adjustment for maximum sensitivity (Refer to par. III-2.f. Maximum Sensitivity Measurement) and adjustment for fast search of a signal.

2. Maximum sensitivity occurs at very narrow sweep widths and 1 KC bandwidth. However, to find a weak signal under these conditions involves painstakingly slow search with the main TUNING MEGACYCLES knob.

3. Maximum ease in finding a signal occurs at a 70 mc sweep width and 80 KC i-f bandwidth.

4. The difference in sensitivity (signal + noise = twice noise) between these two conditions is about 20 db. Therefore, in searching for low level signals, use the following procedure:

(a) CW, AM or FM Modulated Signals.

Control	Setting
SWEEP WIDTH RANGE	0-5 mc (set to 5 mc)
SWEEP RATE	15 cps
VIDEO FILTER	LOW
AMPLITUDE SCALE	LIN
IF BANDWIDTH	MAX
GAIN	Set noise level approx. 1/4 of full scale.

Set other controls as desired. Rotate the TUNING knob slowly over the frequency range of interest. This procedure should give a sensitivity of approximately 10 db lower than maximum possible sensitivity, yet still permit a rapid tuning search.

(b) Pulse Signals.

Control	Setting
SWEEP WIDTH RANGE	0-5 mc, set to 1 mc
SWEEP RATE	15 cps
VIDEO FILTER	OUT
AMPLITUDE SCALE	LIN
IF BANDWIDTH	MAX
GAIN	Set noise level to approx. 1/4 full scale.

Set other controls as indicated in paragraph III-1b. Rotate the TUNING MEGACYCLES knob slowly across the frequency range of interest. This procedure is the best compromise for searching of pulse signals in the order of .5 to 10 μ sec. pulse-width and rep-rate of a few hundred pulses per second to a few thousand pulses per second.

g. MEASUREMENT OF HARMONIC RESPONSES.

1. To measure harmonic responses, inject the signal into the appropriate Input Mixer and set the TUNING MEGACYCLES knob so that the fundamental signal pip can be seen on the Indicator screen.

2. Measure the absolute amplitude of the

fundamental signal (par. III-3.d. above). Make sure that the amplitude is not greater than -40 dbm.

3. Tune to the harmonic under consideration.

4. Measure the amplitude of the harmonic signal (par. III-3.d. above).

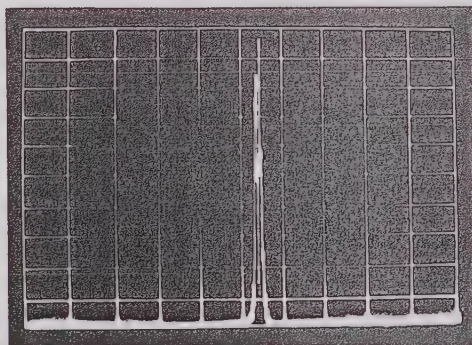
5. Refer to the procedure in paragraph III-2c. Identification of First Mixer Harmonics of the Signal, to determine whether the harmonic response is a true part of the signal or if it is caused by the Spectrum Analyzer. However, if the total input signal is kept below -40 dbm, the Spectrum Analyzer should produce no visible harmonic response.

III-4. NARROW BAND ANALYSIS

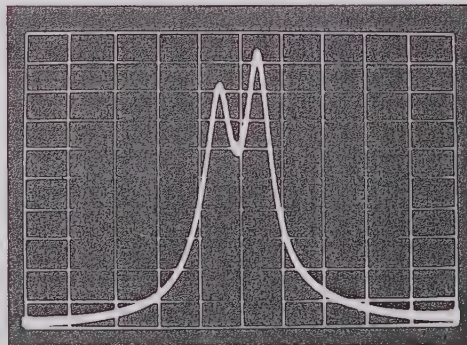
At full sweep width, test signals or a carrier and its sidebands having a small frequency difference, tend to have their corresponding deflections merge into and mask each other. These deflections may be separated (resolved) by increasing the scanning time (reducing the sweep rate), by narrowing the i-f bandwidth at the same time as the sweep rate and/or the sweep width is reduced. (See fig. III-6).

a. USE OF THE VARIABLE IF BANDWIDTH CONTROL.

The variable IF BANDWIDTH control varies the i-f bandwidth of the third (6.5 mc) i-f amplifier. This control is used to separate closely spaced signals, achieve optimum resolution of



a. Two interfering carriers at maximum sweep width.



b. Same signals as "a" at reduced sweep width, resulting in improved separation or resolution.

Figure III-6. Resolution of Interfering Signals.

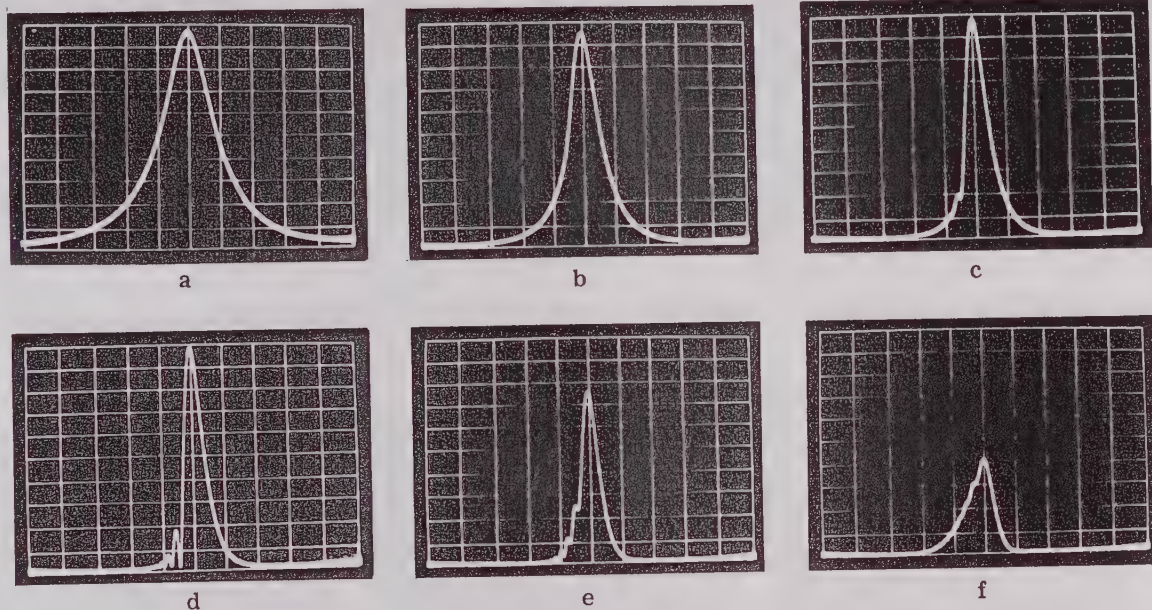


Figure III-7. Ringing as an Indication of Optimum Resolution.

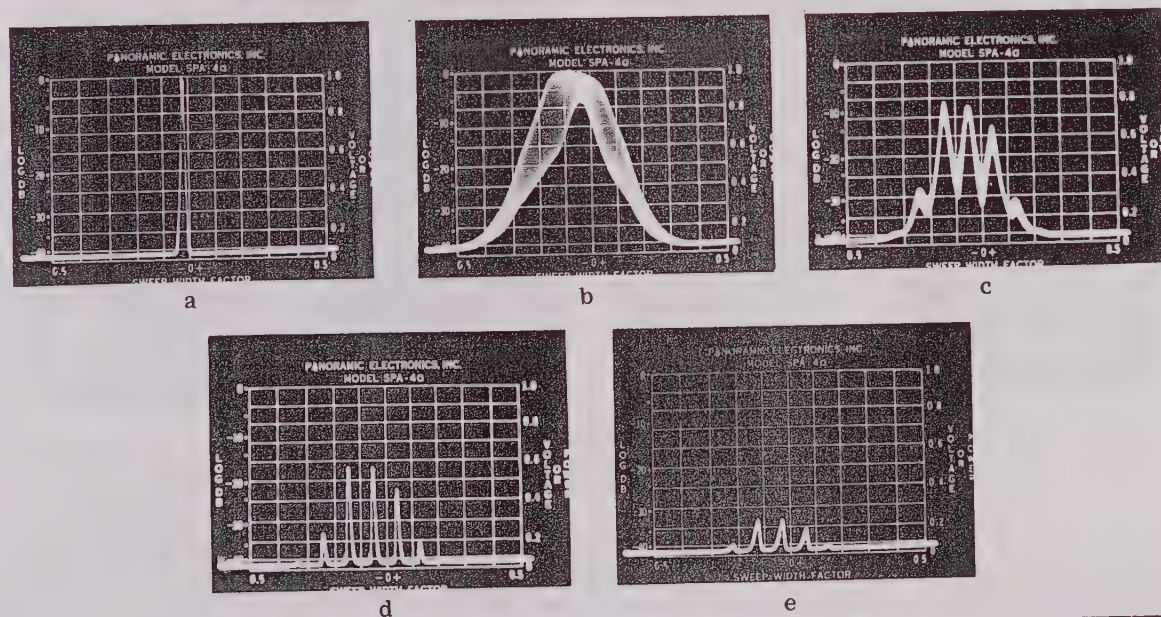


Figure III-8. Separation of Closely Spaced Signals of Equal Amplitude.

signals, to improve the signal to noise ratio of low level signals or to improve the definition and brightness of pulse displays. Waveforms (a) through (f) of Figure III-7 illustrate progressive variations in pip width caused by counterclockwise rotation of the IF BANDWIDTH control. Extent of ringing in (d) shows optimum resolution.

Relative amplitude measurements of two adjacent signals can be made when the two signals are completely resolved. This can be accomplished by the use of the IF BANDWIDTH control.

Figure III-8 (a) through (e) illustrates the progressive separation of closely spaced signals of equal amplitude.

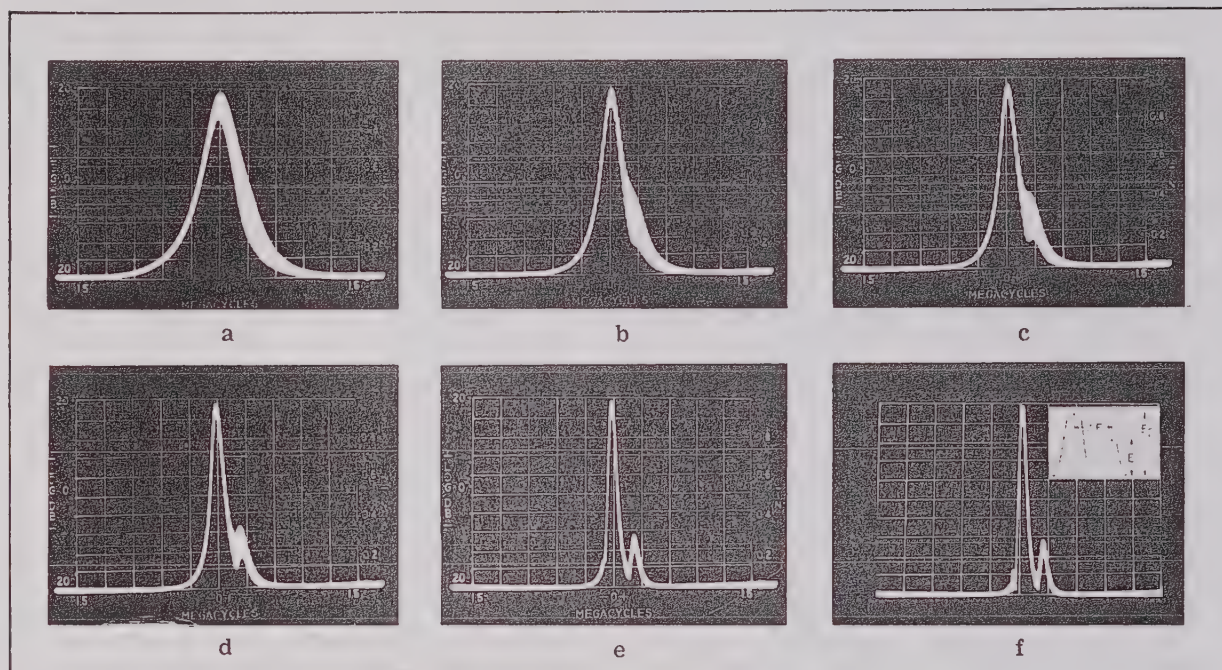


Figure III-9. Resolution of Signals of Unequal Amplitude.

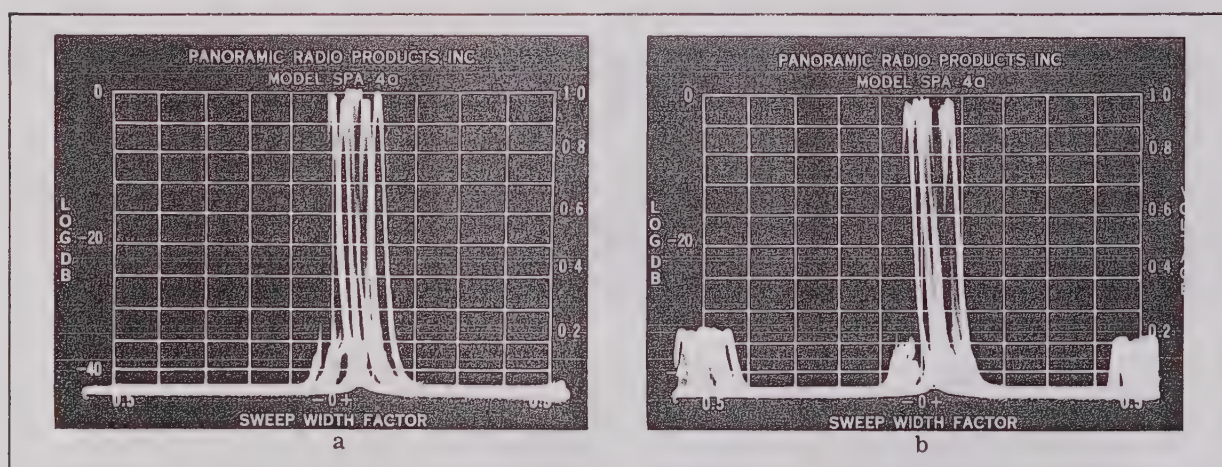


Figure III-10. Spectrum of Incidental FM.

If a signal of small amplitude is close in frequency to a signal of large amplitude, the pip representing the small amplitude signal will be influenced by the large amplitude signal. As the signals separate in frequency, the error becomes less. Waveforms (a) through (f) of Figure III-9 illustrate the progressive variation in pip separation of two signals as the i-f bandwidth is narrowed.

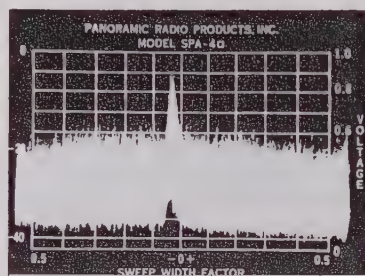
b. INCIDENTAL FM.

Incidental FM will appear as a band of frequencies on the indicator screen. This spectrum

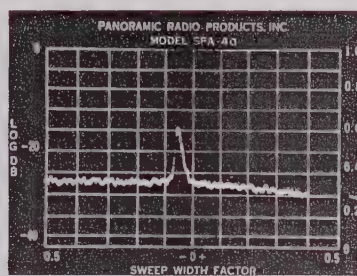
display is caused by a line frequency ripple in the klystron reflector supply as illustrated in Fig. III-10.

c. VIDEO FILTER.

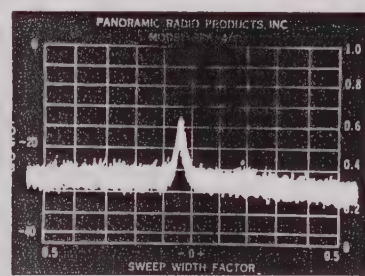
The adjustable VIDEO FILTER is used to smooth or suppress unwanted effects such as noise, spurious beating between adjacent signals, etc., from the signal being viewed. A signal with the VIDEO FILTER set to the OUT position is shown in Fig. III-11a. The same signal with the VIDEO FILTER set to the HI and LOW positions are shown in Fig. III-11b and Fig. III-11c respectively.



a. VIDEO FILTER OUT Po-
sition.

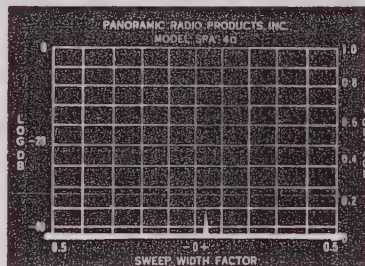


b. VIDEO FILTER HI Po-
sition.

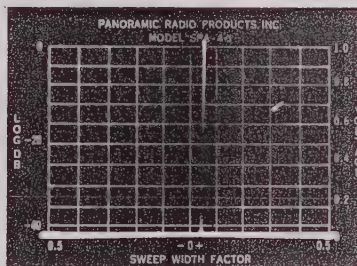


c. VIDEO FILTER LOW Po-
sition.

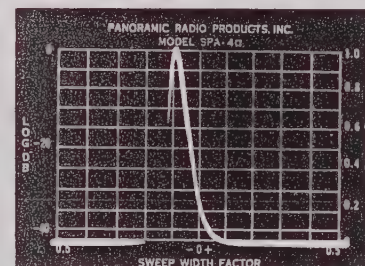
Figure III-11. Video Filter Effects.



a



b



c

Figure III-12. Correct use of the INTENSIFIER Control.

d. USE OF THE INTENSIFIER CONTROL.

When observing pulsed signals, the INTENSIFIER control is turned in a clockwise direction. Noise and pulsed signals will then modulate the CRT beam. Incorrect setting of the INTENSIFIER control will cause wash-out of portions of pulsed signals. Figure III-12, a, b and c illustrate the effects of a lack of intensity (a), correct intensity (b) and over intensity (c).

III-5. INTERPRETATION OF VARIOUS SPECTRA

With a little experience, the operator will be able to recognize the visual character of various types of signals.

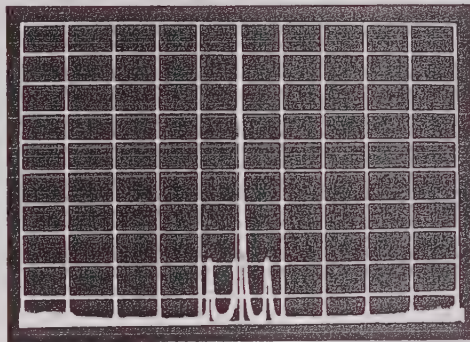
a. AM SIGNALS.

An amplitude modulated carrier appears as a deflection of variable height. Non-constant tone modulation of low frequency will produce a series of convolutions varying in height, their number being determined by the modulator frequency. The nature of the presentation will depend upon the sweep width. See figure III-13a & b.

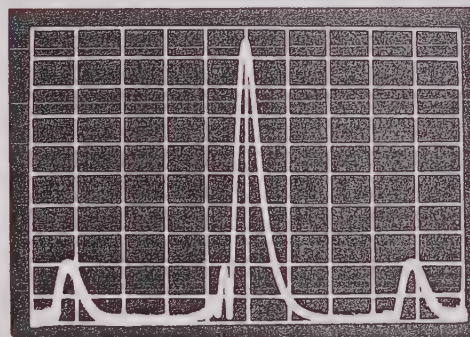
As the modulation frequency increases, the convolutions move toward the two sides of the deflections, as the sidebands tend to become visible. When the modulation frequency is increased, it becomes possible to separate the sidebands by reducing the sweep width of the analyzer. The IF BANDWIDTH control will enable further separation. The higher the frequency of modulation, the farther away those sidebands will move from the center deflections, which represent the carrier. The relative heights of the sidebands may vary as the Tuning knob is turned and as the deflection moves from one end of the screen to the other.

b. BALANCED MODULATION.

The SPA-4a Spectrum Analyzer can be used as an aid in adjusting balanced modulators for minimum transmission of the carrier. This adjustment can be accomplished merely by tuning the Spectrum Analyzer to the carrier frequency of the unit under test. With the use of the balance control on the balanced modulator, adjust the carrier pip for minimum height on the Indicator screen. Balanced modulation will appear as shown in Figure III-14.



a. Amplitude-modulated signal, showing carrier and two sidebands.



b. Same AM signal as "a" at reduced sweep width, carrier remains at center of screen.

Figure III-13. Amplitude - Modulated Signal.

c. FM SIGNALS.

In frequency modulation, the instantaneous carrier frequency varies in accordance with the amplitude of an audio modulating signal. Simple sine wave FM may be conveniently studied mathematically, but differences between the predicted structure and the actual spectrum can be viewed and analyzed with the SPA-4a. Frequency modulated signals, when viewed on the Indicator screen appear as a series of vertical deflections.

Figure III-15a shows FM Modulation with sidebands resolved. (The frequency difference from one pip to the next is the audio frequency). The carrier is balanced out.

Figure III-15b shows the same FM signal, with the sidebands unresolved.

d. PULSE SPECTRA.

A chief use of the Spectrum Analyzer is to check the operation of pulse-modulated trans-

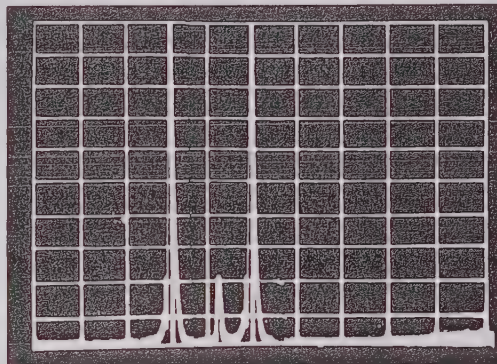
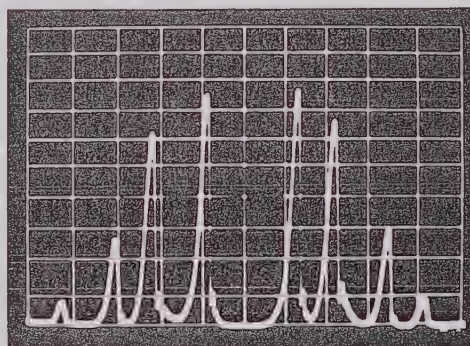
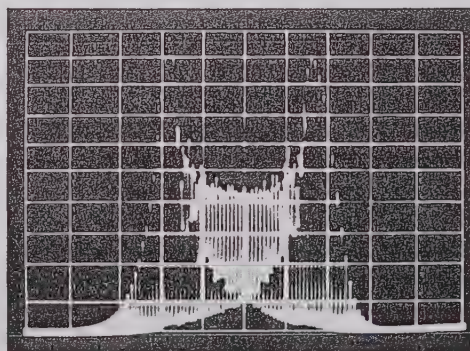


Figure III-14. Spectrum of Balanced Modulation.

mitters. It is used to advantage as a sensitive indicator in checking of excessive frequency modulation of a pulse signal. Excessive frequency modulation tends to remove power from the central lobe of the pulse and broadening the pulse placing excessive power into the side lobes. See figure III-16 a and b. Spectrum of Pulse-Modulated Wave.



a



b

Figure III-15. Spectra of FM Modulated Signals.

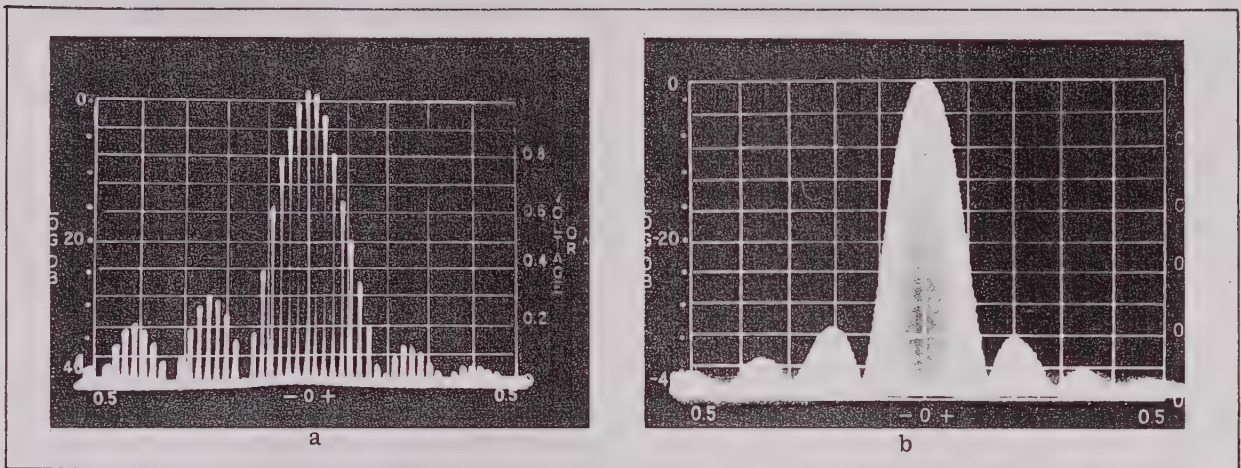


Figure III-16. Spectrum of Pulse-Modulated Wave comparing Fast and Slow Sweep Speeds.

Figure III-16a illustrates spikes, indicating distribution of a pulsed rf signal.

Figure III-16b shows the same signal at a slower sweep speed.

III-6. TYPICAL TEST APPLICATIONS

This section outlines some typical tests performed on radar transmitters and other microwave equipment with the Spectrum Analyzer Model SPA-4a.

a. USE AS A SENSITIVE RECEIVER.

Due to the high sensitivity of the Model SPA-4a, this Spectrum Analyzer can be used to advantage as a sensitive receiver capable of performing many tests, calibrations and measurements, some of which are listed below.

1. Insertion Loss Measurements.

To measure for insertion loss at any particular frequency, use the test set-up shown in figure III-17a.

(a) Set the SPA-4a controls as listed in paragraph III-1b. (MARKER - OFF)

(b) Rotate the TUNING knob until the signal appears on the Indicator screen. If the network under test has a high insertion loss in the order of 40 to 100 db, operation of the SWEEP WIDTH, IF BANDWIDTH and GAIN controls may be necessary to bring the SPA-4a to its maximum sensitivity. (See paragraph III-3f). Operate the signal generator at its maximum calibrated output power.

(c) Adjust the signal generator gain

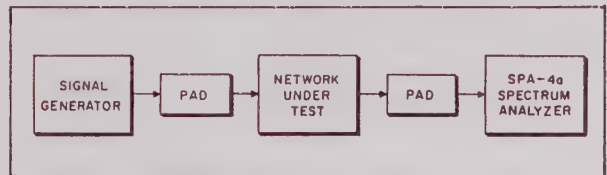


Figure III-17a. Insertion Loss Test Setup.

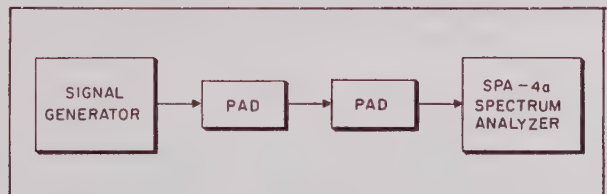


Figure III-17b. Insertion Loss Test Setup.

to give a full scale signal on the indicator screen. Note the signal generator level.

(d) Remove the network under test as shown in figure III-17b.

(e) Reduce the signal generator level to produce a full scale signal on the Indicator screen. Note the new signal generator level.

(f) The difference in power level between the readings in step (c) and (e) is the insertion loss at the specific frequency.

(g) Repeat the above procedure at as many frequencies as desired. In this way, frequency response curves over large frequency ranges and large dynamic ranges can be obtained.

2. Where large variations in response occur over small frequency ranges, these variations can be quickly seen as follows:

(a) Perform the procedure described in steps 1 - (a) and (b) above.

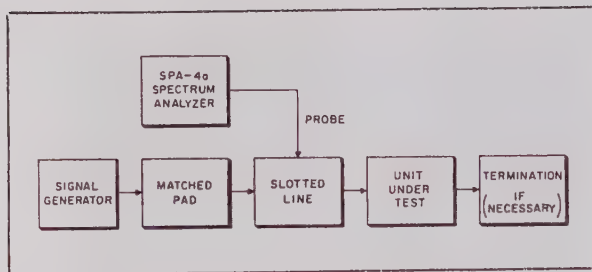


Figure III-18. VSWR Test Setup.

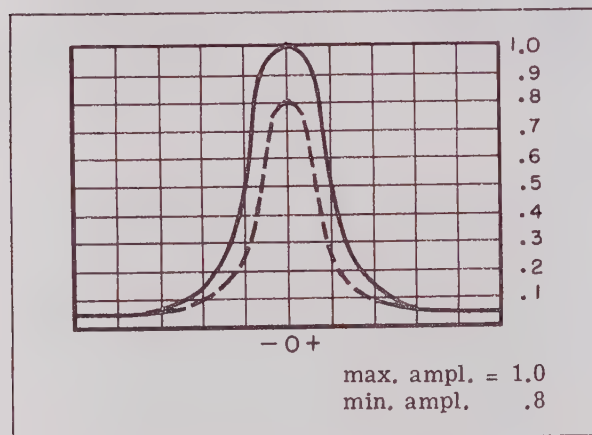


Figure III-19. VSWR Response.

(b) Set the AMPLITUDE SELECTOR control to LOG.

(c) Set the SWEEP WIDTH control as desired.

(d) Set the BANDWIDTH control to maximum if required.

(e) Keeping the signal generator level constant, vary the frequency. The top of the signal pip will trace out the response curve of the network under test.

(f) If very accurate measurements are required, it may be necessary to use the test set-up shown in figure III-17-b and repeat step 2-(e) above. This will check the response of the system, without the test network, for flatness. If this response is not flat, the pip will trace out the correction curve of the system.

3. VSWR measurements can be made by using the SPA-4a as a sensitive receiver in conjunction with a signal generator, matched pad and a Slotted Line. Use the following procedure.

(a) Connect the test setup as shown in Figure III-18.

(b) Set the SPA-4a controls as listed in paragraph III-1b (MARKER-OFF)

(c) Connect the probe to the appropriate INPUT connector on the SPA-4a.

(d) Vary the probe back and forth over the Slotted Line and note the variations in amplitude on the Indicator screen. The degree of change between maximum and minimum signal amplitude will indicate VSWR. See figure III-19.

4. Wavemeter Calibration.

(a) The SPA-4a Spectrum Analyzer can be used in the calibration of wavemeters as a sensitive detector. Using the Indicator screen, a transmission cavity is tuned for maximum deflection of the marker pip.

(b) In tuning a reaction cavity, tune for a minimum deflection of the marker pip on the Indicator screen. Use the test set-up shown in Figure III-20.

5. Use of the Synchroscope Output. The Synchroscope Output jack is located on the Composite Tuning Head front panel of the SPA-4a. This jack has an output impedance of 93 ohms (nominal) and provides the user with a detected signal envelope amplified 60 db.

The Synchroscope Output jack is to be used with an external oscilloscope for signal modulation waveform study.

6. Detection of Audio and FM Signals. The detected output of any audio or FM signal can be obtained simply by rotating the TUNING knob until the desired signal appears at the center of the Indicator screen and using zero sweep.

The detected output, (sloped output for FM) will be available at the VERTICAL OUTPUT jack. It may be necessary to detune the signal slightly in order to obtain an audio output from the VERTICAL OUTPUT jack.

b. VISUAL FREQUENCY COMPARISON.

Visual frequency comparison between a standard frequency and a frequency of interest can be achieved by using the SPA-4a as a sensitive indicator. Use the following procedure.

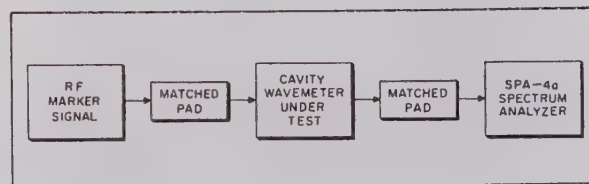


Figure III-20. Test Set-up for Wavemeter Calibration.

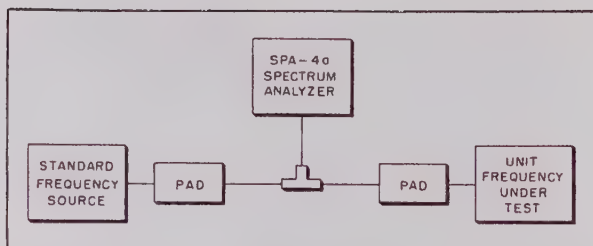


Figure III-21. Visual Frequency Comparison Test Set-up.

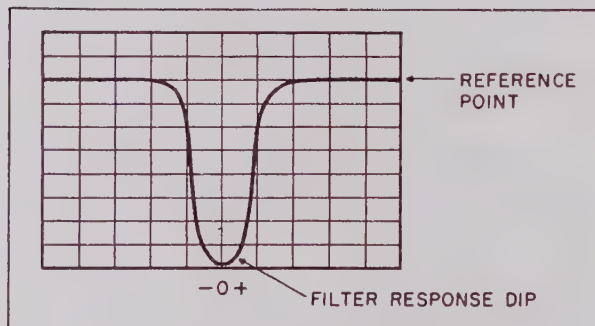


Figure III-22. Filter Response.

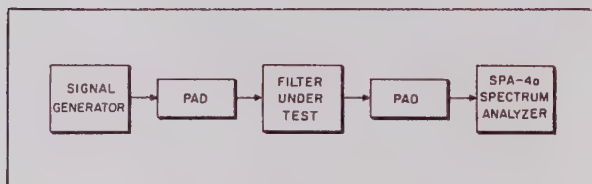


Figure III-23. Test Setup for Filter Response.

1. Connect the test set-up shown in Figure III-21.

2. Set the SPA-4a controls as indicated in paragraph III-1.b. (MARKER-OFF).

3. Rotate the TUNING knob until the standard frequency signal appears at the center of the Indicator screen.

4. Adjust the controls on the unit under test so that its signal appears on the Indicator screen alongside or superimposed with the frequency signal standard.

c. FILTER RESPONSES.

Filter responses can be determined by using the SPA-4a Spectrum Analyzer in conjunction with a signal generator.

1. One method of checking filter responses is to set the signal generator to a known frequency and connect it to the analyzer input. Adjust the input signal level to obtain a reference point

on the Indicator screen. A check should be made at this time to observe the flatness of the Spectrum Analyzer in use. When this has been accomplished, connect the signal generator to the input of the filter under test and connect the output of the filter to the Spectrum Analyzer. Slowly sweeping the input frequency, keeping the signal level constant, the response will appear on the Indicator screen within the frequency range of the filter response. Refer to Fig. III-22 and Fig. III-23 for the filter response test set-up.

2. Another method of checking filter responses is the Insertion Loss method. This is accomplished by setting the signal generator to a known frequency and setting the amplitude to a reference point on the Indicator screen. Keeping the signal generator set at this frequency and amplitude, insert the filter to be tested in series with the signal generator and the Spectrum Analyzer. The response on the Indicator screen will deviate from the reference point. By repeating these steps, changing only the frequency input and keeping the level constant at the reference point on the screen, the technician can plot out the filter response curve by this method. (Refer to step a.1).

d. CHECKING STABILITY OF TRANSMITTERS, OSCILLATORS AND AMPLIFIERS.

Due to the high sensitivity of the SPA-4a Spectrum Analyzer, it can be used to advantage as a sensitive indicator for checking the stability of transmitters, oscillators and amplifiers.

The following paragraphs outline some of the various tests which can be performed with the SPA-4a Spectrum Analyzer.

1. Stability, Microphonics, Incidental FM.

(a) Frequency stability measurements can be made by using the SPA-4a Spectrum Analyzer as a sensitive receiver. When measuring for short term stability, use the following procedure.

(1) Set the SPA-4a controls as listed in paragraph III-1b.

(2) Set the unit under test to its normal operating environment.

(3) Connect the signal to be tested to the appropriate INPUT connector on the SPA-4a.

(4) Rotate the TUNING knob until the signal under test appears on the Indicator screen.

(5) By using the appropriate SWEEP

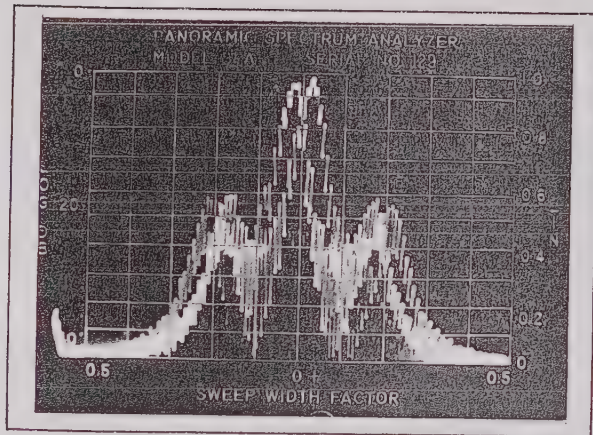


Figure III-24. Screen Presentation Showing Microphonic Effects.

WIDTH RANGE setting (refer to par. I-7) adjust the appropriate MARKER RANGE control until the MARKER pip is in line with the signal pip. Note the MARKER dial setting.

(6) Change the environment of the unit under test to a predetermined level and note the frequency shift.

(7) Adjust the appropriate MARKER RANGE control until the MARKER pip is in line with the frequency shift. Note the MARKER dial setting. The difference in the MARKER dial settings of steps (5) and (7) will indicate the frequency shift of the unit under test.

(b) When measuring for long term stability, the use of an external Crystal Marker is advisable. Although the SPA-4a is a very versatile and accurate test instrument, its MARKER oscillator is not crystal controlled, therefore, not very stable over long periods of operation. In performing long term stability checks, use the same procedure as given for short term stability checks. The only difference is that the external Crystal Marker is used in place of the SPA-4a MARKER.

(c) Microphonics can be viewed on the SPA-4a Spectrum Analyzer by performing the following procedure.

(1) Set the SPA-4a controls as listed in paragraph III-1b. (MARKER - OFF).

(2) Connect the signal to be tested to the appropriate INPUT connector on the SPA-4a.

(3) Rotate the TUNING knob until the signal under test appears at the center of the Indicator screen.

(4) Adjust the SWEEP WIDTH control until a suitable display of the signal is present. Microphonic content can be identified as noise or distortion of the signal under test. See Figure III-24.

2. Squegging. Squegging of an oscillator can be defined as recurrent interruptions of oscillations at an audio or RF rate. Since the spectrum of squegging in an oscillator resembles the spectrum of a pulse-modulated wave, it therefore contains sideband components in addition to the oscillator frequency.

By utilizing the Indicator screen, the output of a continuous oscillator can be viewed for spectral purity and squegging.

3. Spurious Signals. The SPA-4a Spectrum Analyzer can be used to advantage, when properly used, as an indicator in checking for spurious signals of oscillators, amplifiers and transmitters. This can be accomplished by first formulating a chart of the known frequencies of the equipment under test. Then, by using a filter to filter out the known frequency to the Spectrum Analyzer, the technician can sweep across the Indicator screen and seek out spurious signals. Spurious signals will be those signals which appear on the Indicator screen but which are not on the formulated chart of known frequencies of the equipment under test.

4. Incidental FM of SPA-4a Spectrum Analyzer (Marker signal).

The following procedure is a quick method of checking incidental f-m of the circuits following the marker oscillator in the SPA-4a Spectrum Analyzer. This method will give a useful calibration but the calibration should not be considered an accurate one.

(a.) Preliminary Setup.

(1.) Set the SWEEP WIDTH RANGE control for narrow-band operation (0-5 MC).

(2) Set the MARKER pip at the center of the Indicator screen.

(3.) Set the GAIN control to show 1/16 inch of noise on the Indicator screen.

(4.) Set the CAL-SYNC SEL control to the CAL position.

(5.) Set the SYNC AMPL control fully counterclockwise.

(6.) Adjust the SWEEP RATE control fully clockwise. This should provide a sine wave display on the screen greater than 60 cps.

(7.) Set the CAL-SYNC SEL control to the EXT position.

(8.) Adjust the SWEEP WIDTH CONT control counterclockwise, and at the same time, adjusting the I-F BANDWIDTH control counterclockwise until optimum resolution is obtained. (See par. III-4a.)

Continue adjusting both controls counterclockwise until the MARKER pip shows a deviation of at least 1/2 division. Use the CENTER FREQUENCY knob to keep the pip centered on the Indicator screen.

(9.) When the 1/2 division of deviation is obtained in a readable presentation, connect an audio signal generator to the MARKER MOD jack through a 10 or 20 db pad.

(10.) Adjust the audio signal generator until sideband pips appear across the full screen scale.

(11.) Divide the audio signal generator frequency by ten. This will indicate the incidental f-m of the Narrow-Band Sweep Oscillator and all circuits following it.

All SPA-4a units, with serial numbers 151 and above, should show a deviation ranging between 150 cps and 1000 cps, depending upon the condition of V804, V805, V806, the low voltage power supply and the DC Filament supply in that order.

(b.) Incidental FM of an External Signal.

Incidental f-m of an external signal through the SPA-4a Spectrum Analyzer, including the local oscillator, may be obtained by using the following procedure. This method is to be used for bands 1 through 5 only, for it is not practical to measure the higher bands directly.

(1.) Obtain a signal generator known to have a low incidental f-m such as the Hewlett-Packard #608 or #612 in good condition.

(2.) Tune the SPA-4a Spectrum Analyzer to the r-f frequency under test.

(3.) Tune the signal generator to the same r-f frequency as the frequency under test.

If the desired frequency is too high for the signal generator, use the highest fundamental frequency of the signal generator which will provide a harmonic signal at the desired frequency.

(4.) When the signal is obtained at the desired frequency, adjust the deviation of the

signal in the same manner as in paragraph (a) steps (1) through (8).

(5.) Center the MARKER pip on the Indicator screen and using the audio signal generator to provide sidebands, measure the deviation in the same manner as described in paragraph (a) steps (9) through (11). This will indicate the incidental f-m of the SPA-4a Spectrum Analyzer.

(6.) Using the signal under test in the same manner as the signal generator signal, repeat steps (1) through (5) above.

The incidental f-m of the signal under test can then be determined by subtracting the figure obtained in step (5) above, from the figure obtained in this step.

To repeat, the procedure given above is only a quick method of checking incidental f-m. This method will give a useful calibration but should not be considered as accurate.

e. MONITORING OF COMMUNICATION BANDS, SPILL-OVER.

Due to the high sensitivity of the SPA-4a, the Spectrum Analyzer can be used with great advantage in monitoring communication bands and spill-over.

1. Monitoring of communication bands can be accomplished by utilizing the Indicator screen. A check of frequency drift, signal level drop, stability and modulation characteristics can be quickly analyzed. For further explanation of the various checks mentioned, refer to the Table of Contents.

2. Spill-over can be checked by monitoring the output frequency of the equipment under test on the Indicator screen. By observing the bandwidth of the signal under test, the user can note if the signal is exceeding or spilling over its allotted tolerance.

f. RFI MEASUREMENTS, SPECTRUM SIGNATURES.

1. Spurious outputs of transmitters can be found by using the SPA-4a Spectrum Analyzer as a frequency-selective voltmeter or power measuring device. The following is the procedure used to scan the spectrum, locate, measure and record the spurious output of the transmitter under test.

(a) Connect the test components as shown in figure III-25.

(b) Tune the transmitter under test to a standard frequency.

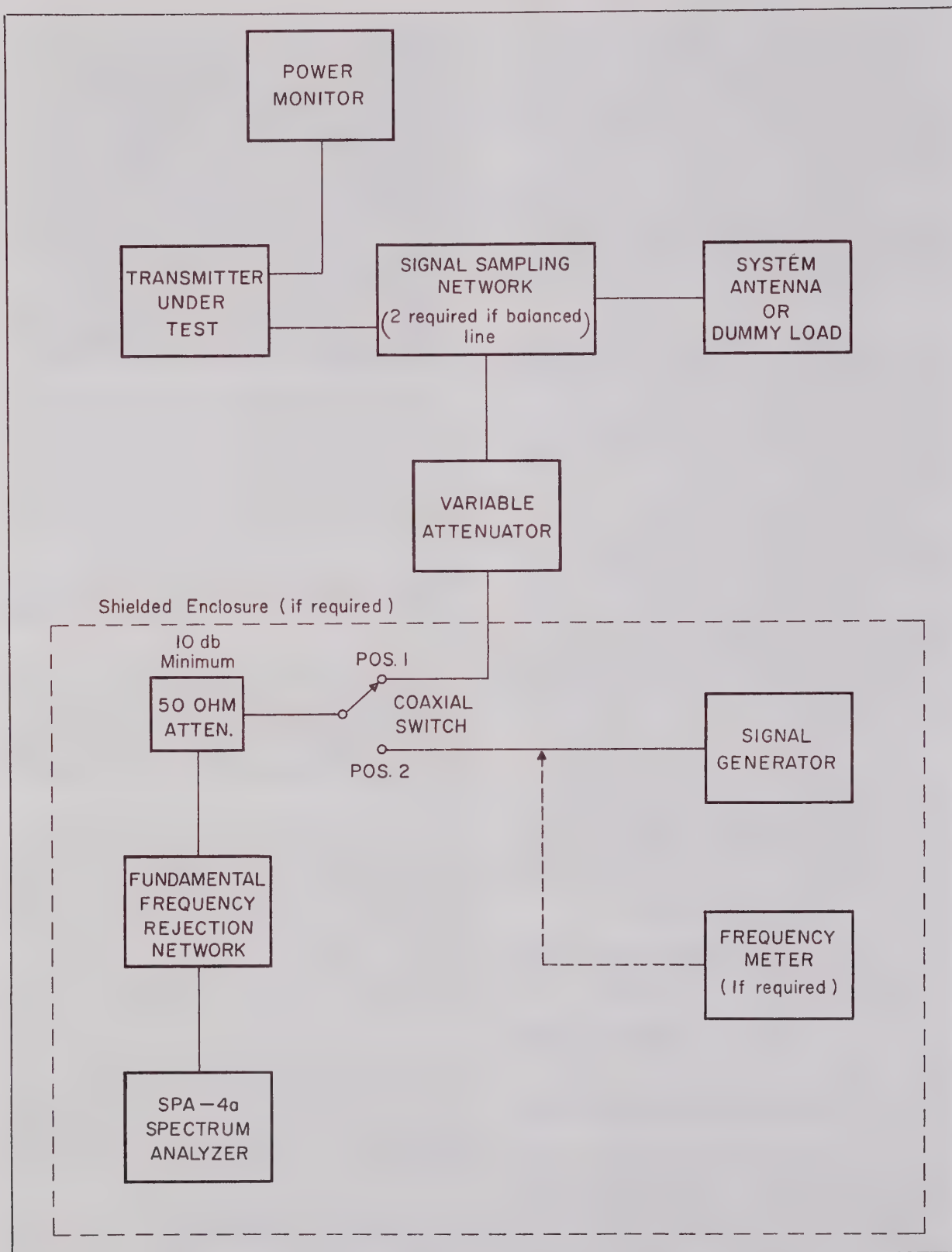
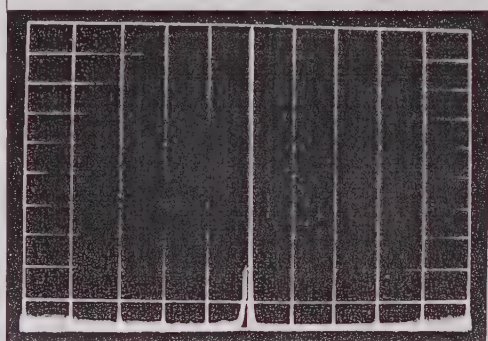
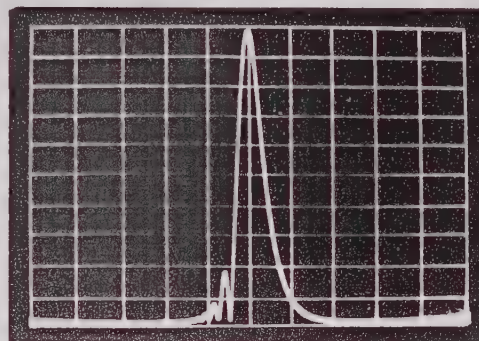


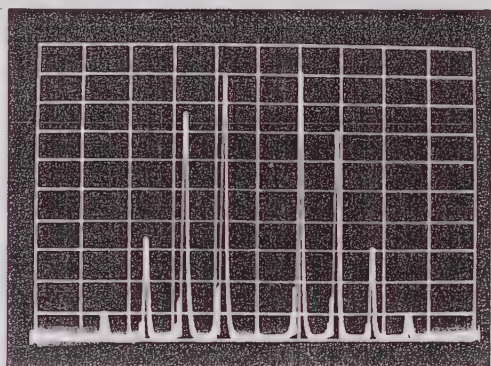
Figure III-25. Transmitter Output Measurement Set-up.



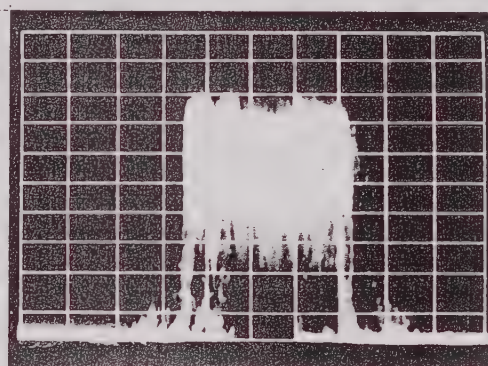
a. Constant carrier signal at approximately maximum sweep width.



b. Appearance of constant carrier at reduced sweep width.



c. Frequency distribution of an FM signal.



d. Major regions of FM system sideband energy due to speech modulation.

Figure III-26. Appearance of Typical Panoramic Indications.

(c) Set the SPA-4a controls as listed in paragraph III-1b. (MARKER-OFF)

(d) Set the coaxial switch to position 1.

(e) Connect the signal under test to the appropriate INPUT connector on the SPA-4a, bypassing the Fundamental Frequency Rejection Network.

(f) Tune the SPA-4a to the fundamental frequency of the transmitter under test by rotating the TUNING knob until the signal appears on the Indicator screen and by observing the dial scale reading.

(g) Connect the Fundamental Frequency Rejection Network as shown in figure III-25. The signal on the Indicator screen should then disappear.

(h) Set the GAIN control for maximum amplitude.

(i) Rotate the TUNING knob to scan across the frequency bands of interest.

(j) When a spurious signal is found, check its frequency by reading the dial scale.

NOTE

Be sure that the spurious responses being measured are not those generated by the SPA-4a. Refer to paragraph III-2.

(k) Adjust the GAIN control to obtain a full scale screen indication of the spurious signal.

(l) Set the coaxial switch to position 2.

(m) Set the signal generator to the same frequency as the spurious signal.

(n) Adjust the signal generator level to obtain a full scale indication on the Indicator screen.

(o) Record the signal generator level.

(p) Repeat the above procedure, scanning across the entire frequency band of interest, until the frequencies and levels of all spurious outputs are found.

2. Various types of spectrum signatures can be quickly identified and analyzed with the use of the SPA-4a Spectrum Analyzer. With a knowledge of the various wave shapes and pulse characteristics shown in this manual, the user can identify and analyze interfering signals, presence and frequency of RF signals, modulation characteristics, distortion, etc. See figure III-26 for typical screen indications.

g. SIGNAL STRENGTH METER-VOLTMETER.

Signal strength and voltage measurements can be made by using the SPA-4a Spectrum Analyzer as a sensitive receiver.

1. For use of the SPA-4a as a signal strength meter, use the following procedure.

(a) Set the SPA-4a controls as listed in paragraph III-1b. (MARKER-OFF)

(b) Calibrate the SPA-4a with a known signal level.

(c) Connect the signal to be tested to the appropriate INPUT connector on the SPA-4a.

(d) By using any of the AMPLITUDE SCALE switch positions, the signal strength, of the signal under test, can be read directly from the Indicator screen. For proper use of the AMPLITUDE SCALE switch positions, refer to paragraph III-3a.

2. For use of the SPA-4a as a voltage measuring device, use the following procedure.

(a) Set the SPA-4a controls as listed in paragraph III-1b. (MARKER-OFF).

(b) Calibrate the SPA-4a with a known voltage.

(c) Connect the signal to be tested to the appropriate INPUT connector on the SPA-4a.

(d) With the AMPLITUDE SCALE switch set to the LIN position, voltage readings can be taken using the right-hand screen calibrations. For proper use of this position, refer to paragraph III-3a.1.

CHAPTER IV THEORY OF OPERATION

IV-1. GENERAL

The Panoramic Spectrum Analyzer, Model SPA-4a, is a device used for determining the frequency-energy distribution of a signal or group of signals. The Model SPA-4a is a selective superheterodyne microwave receiver which is cyclically tuned through the desired radio-frequency band. The receiver output is displayed on the vertical axis of a cathode-ray tube. The horizontal sweep rate of the CRT is related to the receiver sweep rate, thereby giving a visual indication of the frequency and relative strengths of signals present in the band being scanned. The excursion of the displayed frequency band is determined by the frequency sweep of the local oscillator. The selectivity or frequency resolution is determined by the i-f bandwidth and sweep speed. Three different local oscillators are used to cover the

tuning range. Fundamentals and harmonics of the local oscillator frequencies are used, and are described in Section I-5.

A block diagram of the Model SPA-4a is shown in Fig. IV-1. The tuning unit contains the three local oscillators with their associated transmission line circuits, the tracking potentiometers for the Klystron repeller voltages, mixers and attenuators for the various inputs, the six-position pushbutton band switching mechanism, the tuning mechanism, and the coaxial switches and relays for switching circuits into the system. The indicator unit contains the i-f amplifiers, the video amplifier, the horizontal sweep generator, and the marker oscillator, as well as the cathode-ray tube. The low-voltage power supply, the Klystron power supply and the cathode-ray tube power supply are mounted in the back of the main frame.

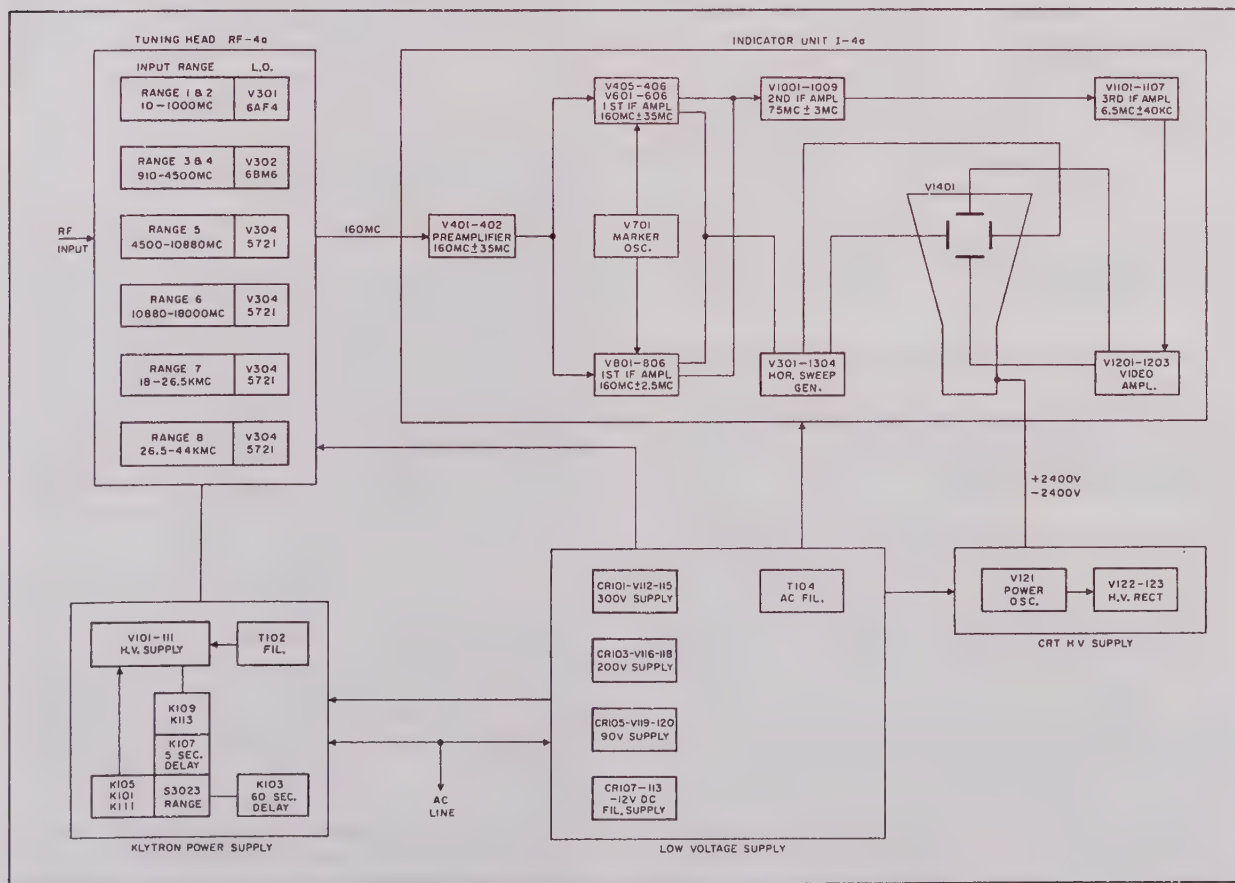


Figure IV-1. Block Diagram of Spectrum Analyzer, Model SPA-4a.

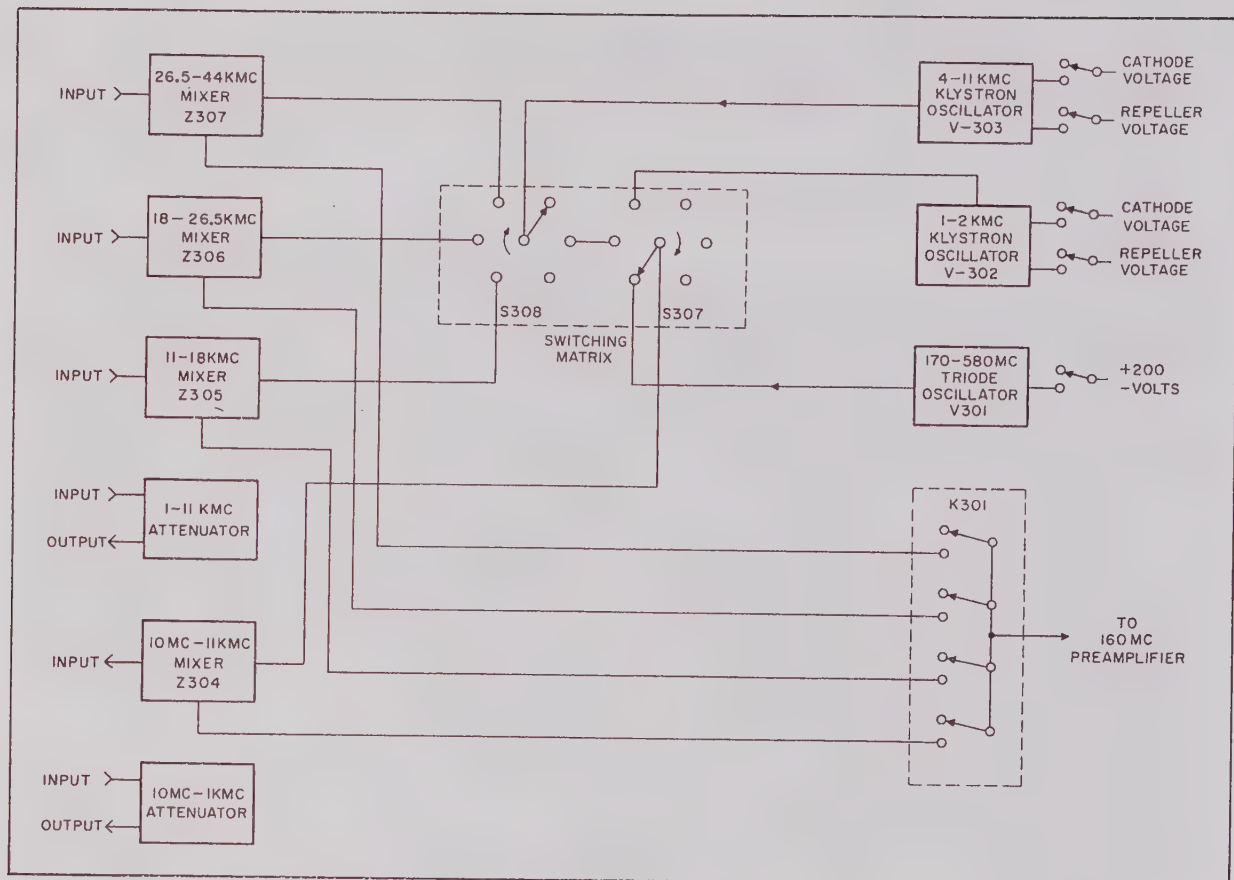


Figure IV-2. Block Diagram of Composite Tuning Head, Model RF-4a.

IV-2. COMPOSITE TUNING HEAD, MODEL RF-4a

The block diagram of the Composite Tuning Head is shown in Fig. IV-2. Circuit connections for the various settings of the RANGE switch are shown in Figs. IV-3 through Fig. IV-8, See Schematic circuit diagram drawing number P6-15224 for supporting information.

a. The local oscillator for BANDS 1 and 2 consists of a 6AF4 triode tube in a tuned transmission line oscillator circuit. In BAND 1 (10 to 420 MC), the fundamental frequency of the local oscillator is tuned 160 MC above the incoming signal. In BAND 2 (350 to 1000 MC), the second harmonic of the local oscillator is tuned 160 MC above the incoming frequency and is used to heterodyne with the incoming signal. The parallel transmission line operates in a $1/4$ wave mode and is tuned by changing the position of a contacting short circuit. Changing the frequency dial setting changes the position of the contacting short circuit to obtain proper operating frequency of the oscillator. In BANDS 3 and 4, a 6BM6

Reflex Klystron tube is employed as the first local oscillator. In the lower band of operation (910 to 2200 MC), the fundamental frequency of the local oscillator is used and is tuned to 160 MC higher than the signal frequency. In the higher band of operation (1980 to 4560 MC), the second harmonic frequency of the local oscillator is used to heterodyne with the incoming signal, and in this band the second harmonic frequency is 160 MC higher than the signal frequency. In BANDS 5 through 8, a 5721 Klystron is used; in BAND 5 (4500 to 10,880 MC), the fundamental frequency of the local oscillator is used; in BAND 6 (10.88 to 18.0 KMC), the second harmonic is used; in BAND 7 (18.0 to 26.4 KMC), the third harmonic of the oscillator is used; and in BAND 8 (26.4 to 44.0 KMC), the fourth harmonic is used; in each band the respective fundamental or harmonic frequency is tuned to 160 MC above the signal frequency.

The six-button band selector switch selects the proper local oscillator by applying plate voltage to only that tube which is being used. The tuning drive moves a non-contacting, short-

circuited plunger inside the cavity to tune it to the proper frequency. The voltage applied to the reflector electrode of the Klystron tube in use is simultaneously tracked with the tuning dial position by means of a tracking potentiometer ganged to the tuning mechanism.

b. RF INPUT MIXERS.

Silicon crystal diodes are employed in the mixers. A single mixer is used for BANDS 1 to 5, and individual mixers for BANDS 6, 7, and 8. The appropriate mixer for the band in use is selected by Coaxial Relay J301. The proper harmonic of the oscillator in use beats with the input signal and produces an output frequency of 160 MC as shown in the block diagram.

c. ATTENUATORS.

In addition to the direct inputs on all bands, attenuators are provided for BANDS 1 to 5. These attenuators provide for attenuation of strong input signals which might otherwise overload the input.

IV-3. INDICATOR UNIT, MODEL I-4a

The block diagram of the Indicator Unit is given in Fig. IV-9a, b, c. The schematic circuit diagram drawing numbers are P6-15225-1/3 and 2/3.

a. 160 MC I-F AMPLIFIER.

The input signal from the tuning head is first taken to a 160-MC wideband preamplifier. The output of this preamplifier is then switched to either a wideband 160 MC amplifier, or through two filters to a 160-MC narrow-band amplifier. The outputs of these two i-f amplifiers are taken to a 0 to 70 MC or to a 0 to 5 MC sweeper, respectively. The marker frequency is inserted at the i-f amplifiers as shown. The SWEEP WIDTH RANGE switch connects the desired i-f amplifier into the circuit, and removes plate voltage from the one not in use. Mixing is done in the sweeper circuits, using triode mixers (V604 in the wide-band sweeper and V804 in the narrow-band sweeper).

b. 75 MC I-F AMPLIFIER.

The output of the wide or narrow band sweeper (whichever is used) is at a frequency of 75 MC and this is taken to a second i-f amplifier consisting of tubes V1001 through V1004. An output from the 75 MC i-f amplifier is taken to a detector and a pulse amplifier to produce a synchroscope output point at which the modulation of any signal to which the unit is tuned may be observed upon the screen of a synchroscope. The output of the 75 MC i-f amplifier is then heterodyned against another local oscillator signal to produce a third i-f signal at a frequency of 6.5 MC.

c. 6.5 MC I-F AMPLIFIER.

The 6.5 MC output signal from the second i-f amplifier is taken to a third i-f amplifier tuned to 6.5 MC, consisting of V1101 through V1105. The bandwidth of this i-f amplifier is adjusted by the dual potentiometer R1125 which changes the bandwidth by introducing damping to change the Q's of tuned Inductors L1101 and L1103.

d. LIN-LOG POWER DETECTOR.

The output of the 6.5 MC i-f amplifier is taken to an untuned detector which provides means of attaining either linear, logarithmic, or exponential type of indication. Selection of the type of response is made through the AMPLITUDE SCALE switch. When the switch is set in a LIN position, V1106 acts as a simple linear amplifier and its output signal is detected by diode V1107. In the LOG position of the switch, a portion of the detected signal voltage is fed back as grid bias; this bias voltage is proportional to signal level, therefore, as bias increases, the gain of the stage decreases. Signals of high level will therefore be amplified to a lesser degree than low-level signals, and consequently, will appear compressed; the extent of this compression is determined by the setting of the Log Scale Adjust Control, which is used to shape the I_p curve of the tube to conform with the log zero position on the cathode-ray tube screen. In the POWER position, a positive detected signal from V1107 is fed back to the grid of V1106; this voltage is proportional to signal level, therefore, as the signal level increases, the gain of the stage increases. The resistor values have been selected, such that a square law detector characteristic is obtained.

e. MARKER OSCILLATOR.

The marker oscillator consists of a dual triode V701 in a butterfly oscillator circuit, whose frequency of oscillation is determined by coarse and fine tuning controls. This oscillator obtains its plate voltage and may be plate-modulated through the modulator output stage V702.

f. SWEEP (REACTANCE) OSCILLATOR CIRCUIT.

This circuit provides the sawtooth modulated converter frequency which produces the panoramic display on the cathode-ray tube screen. A sawtooth voltage from the horizontal sweep generator produces a current in the control winding of a variable inductor which controls the oscillator frequency. The extent of frequency excursion is determined by the amplitude of the applied sawtooth; the sweep width control governs this ampli-

tude and consequently controls the scanning width. The wideband sweep oscillator consists of tubes V601 to V606. The narrow-band sweep oscillator consists of V804 to V806 and uses the fundamental frequency of the oscillator.

g. SWEEP GENERATOR.

The horizontal sweep generator consists of tubes V1301 to V1304. The sawtooth voltage is generated in the circuit consisting of V1302, V1303 and DS1301 (an NE-16 neon lamp) and associated RC networks. V1302 acts as a Miller type sweep generator, V1303 is a cathode follower feedback and output tube, and the resistance-capacitance network (C1309, R1323, R1325A, R1325B, R1327, and R1331) in the grid circuit of V1301 determines the time constant of the generator. The sweep circuit is triggered by pulses from V1301, which amplifies the synchronizing signal (selected by S1301), differentiates and shapes it into positive-going pulses, and applies these pulses to an electrostatic coating on the neon tube to change its firing level. The output sawtooth voltage from V1303 is amplified by V1304 to a push-pull signal at a level which will produce a sufficient spot deflection on the screen of the cathode-ray tube. The signal from the plate of V1304A is also taken to the input of the blanking amplifier. The sawtooth voltage from the cathode

of V1303 is also taken to the wide-band and narrow-band sweep oscillators to control the frequency sweep of the display on the cathode ray tube screen.

h. VIDEO AMPLIFIER.

The video amplifier includes a phase inverter and push-pull amplifier stage V1201 which drives the vertical deflection plates of the cathode-ray tube, an intensifier circuit which increases the brightness of peaks of sharp pulses to improve their visibility, and the cathode-ray tube blanking amplifier. The output signal from the 6.5 MC detector is amplified in the 1st half of V1201 and applied to one of the vertical deflection plates of the cathode ray tube; a portion of the signal at the plate is inverted in phase and amplified in the second half of V1201 and applied to the other vertical deflection plate. Capacitor C1201 or C1203 may be switched into the grid circuit of V1201 to form a low-pass filter for removing high-frequency noise from the screen presentation. An output signal from the vertical amplifier is taken to one section of V1202 and amplified, then applied to the control grid of the cathode-ray tube in such a manner that when a signal appears on the screen a positive voltage pulse is applied to the grid to increase the brightness at the peak of the signal deflection. The

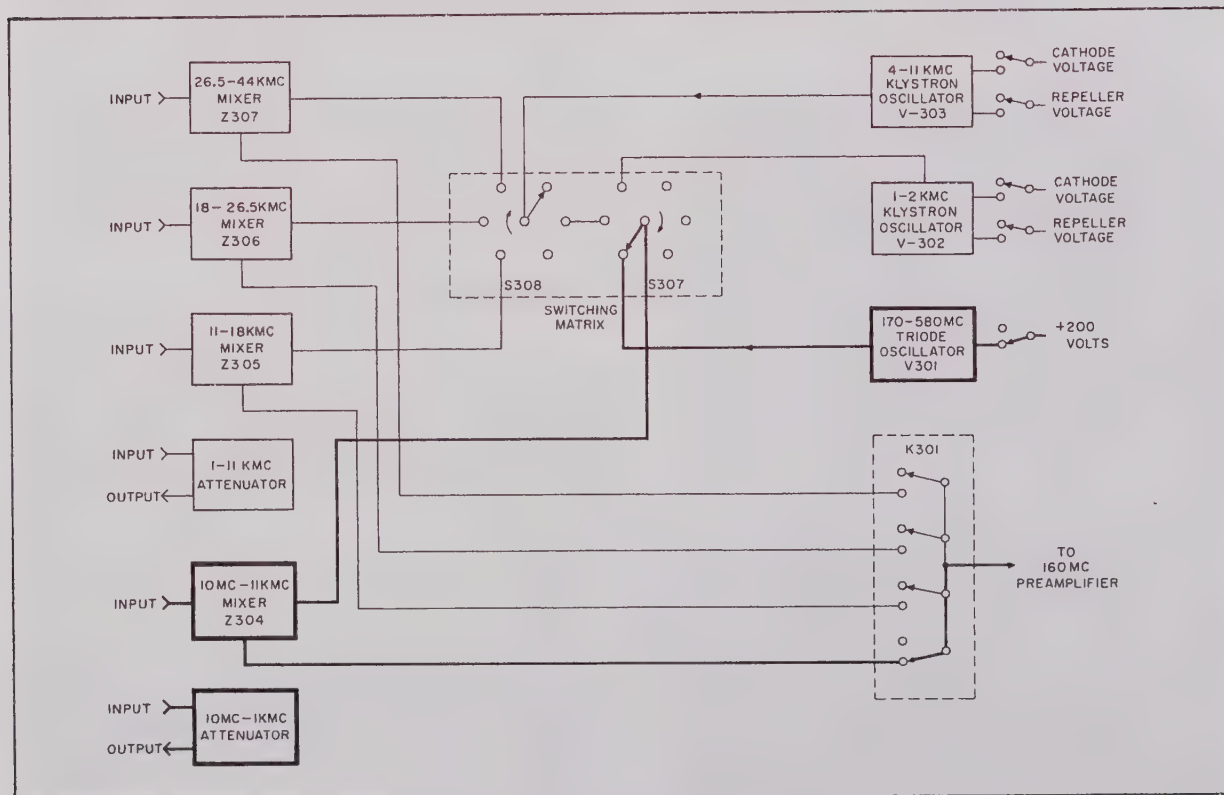


Figure IV-3. Block Diagram of Composite Tuning Head, RF-4a (Range 2/1).

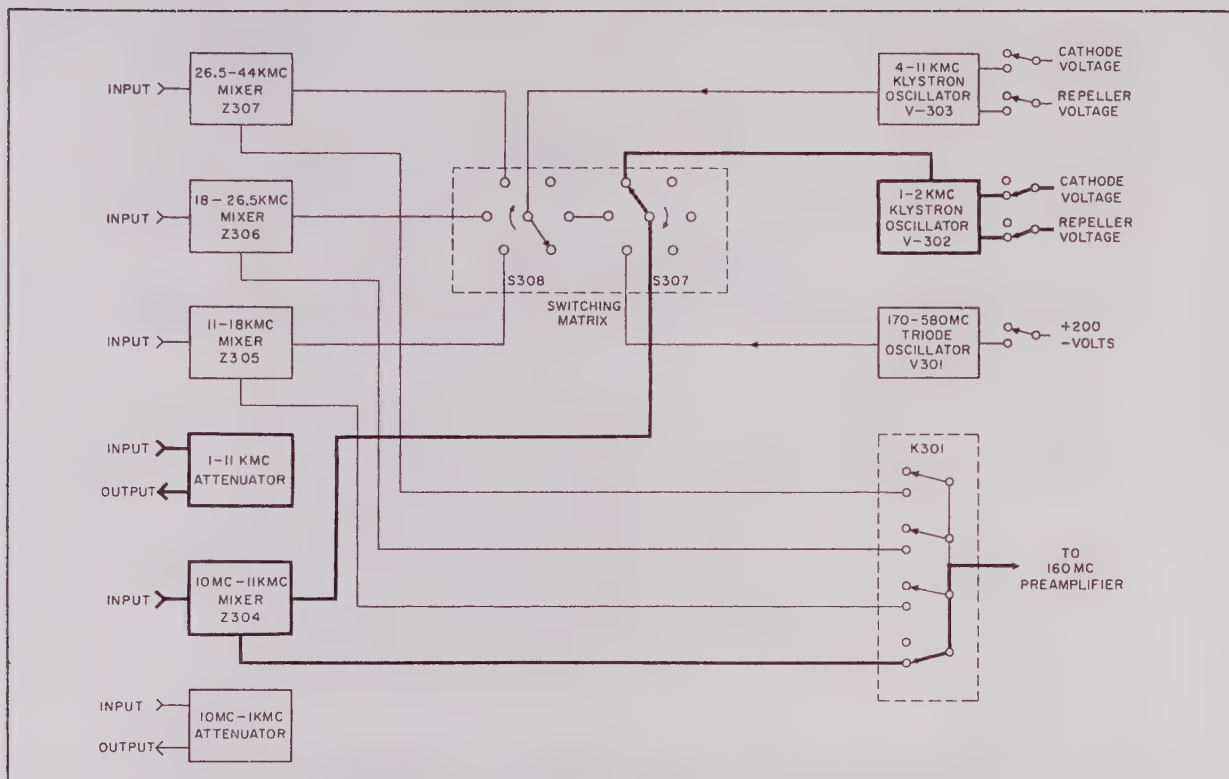


Figure IV-4. Block Diagram of Composite Tuning Head, RF-4a (Range 4/3).

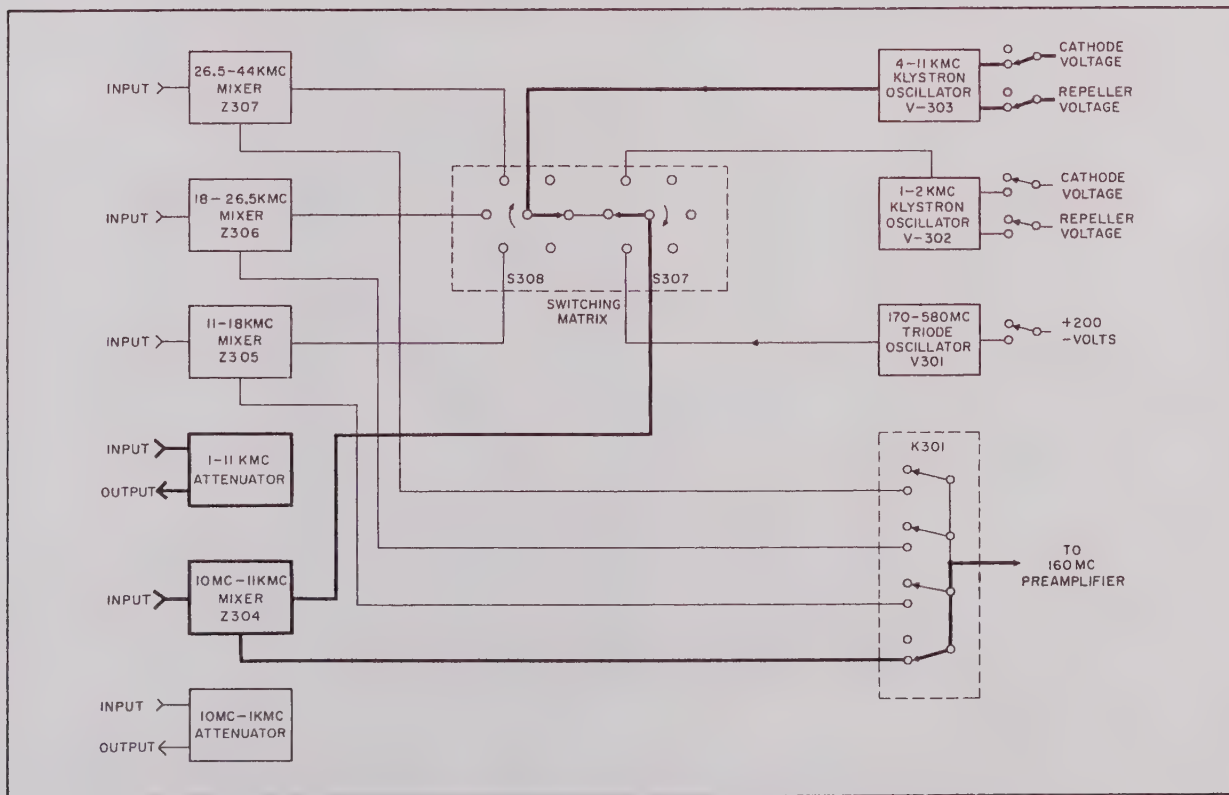


Figure IV-5. Block Diagram of Composite Tuning Head, RF-4a (Range 5).

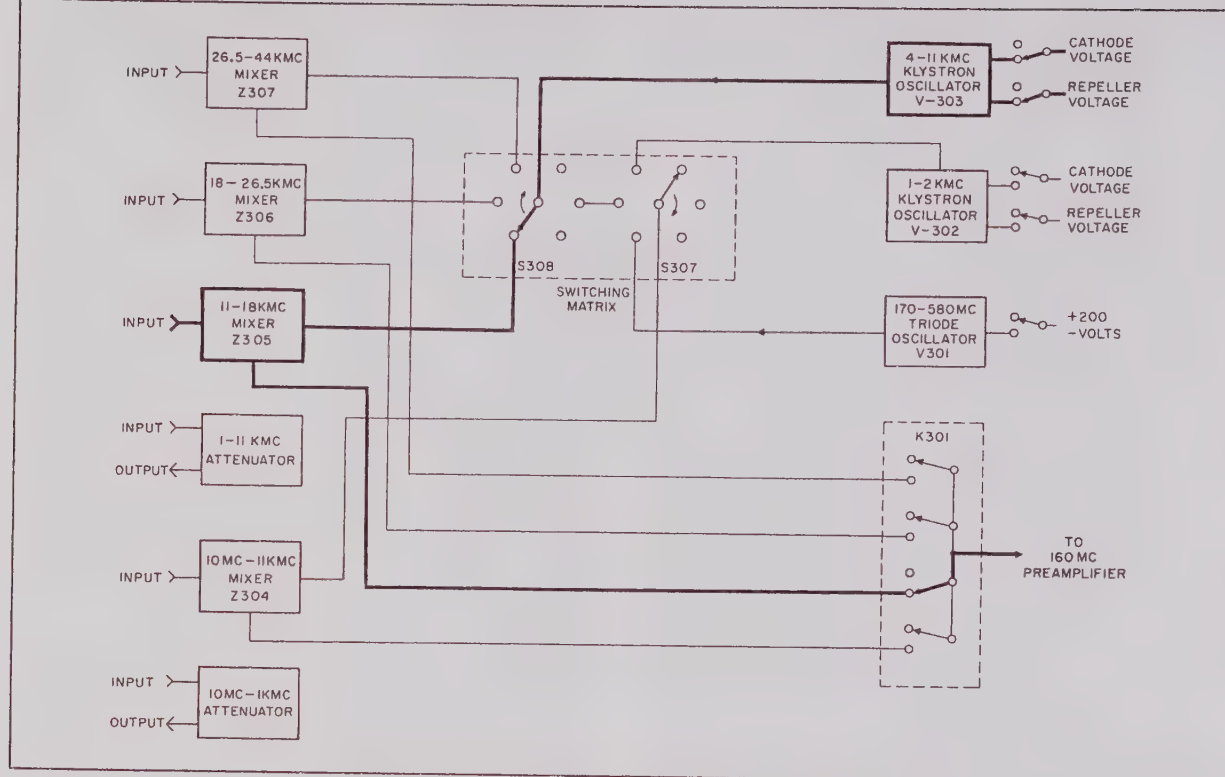


Figure IV-6. Block Diagram of Composite Tuning Head, RF-4a (Range 6).

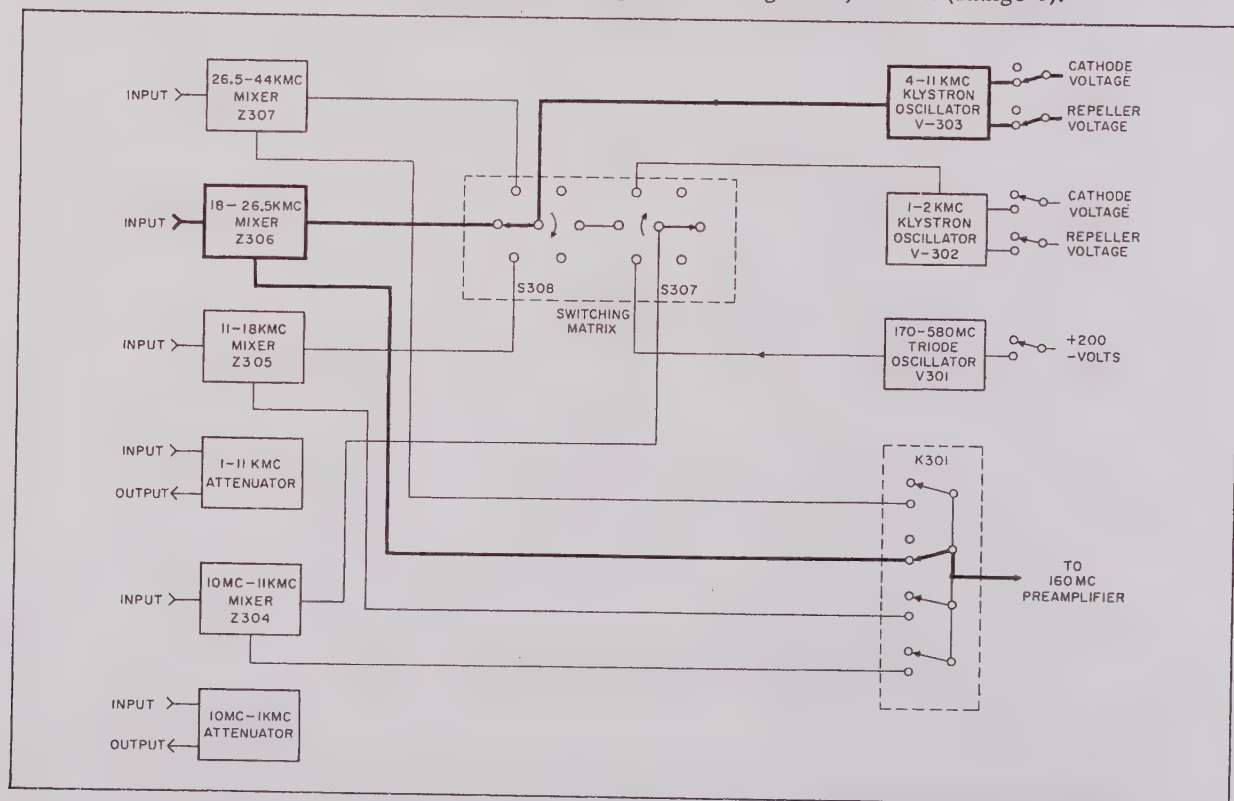


Figure IV-7. Block Diagram of Composite Tuning Head, RF-4a (Range 7).

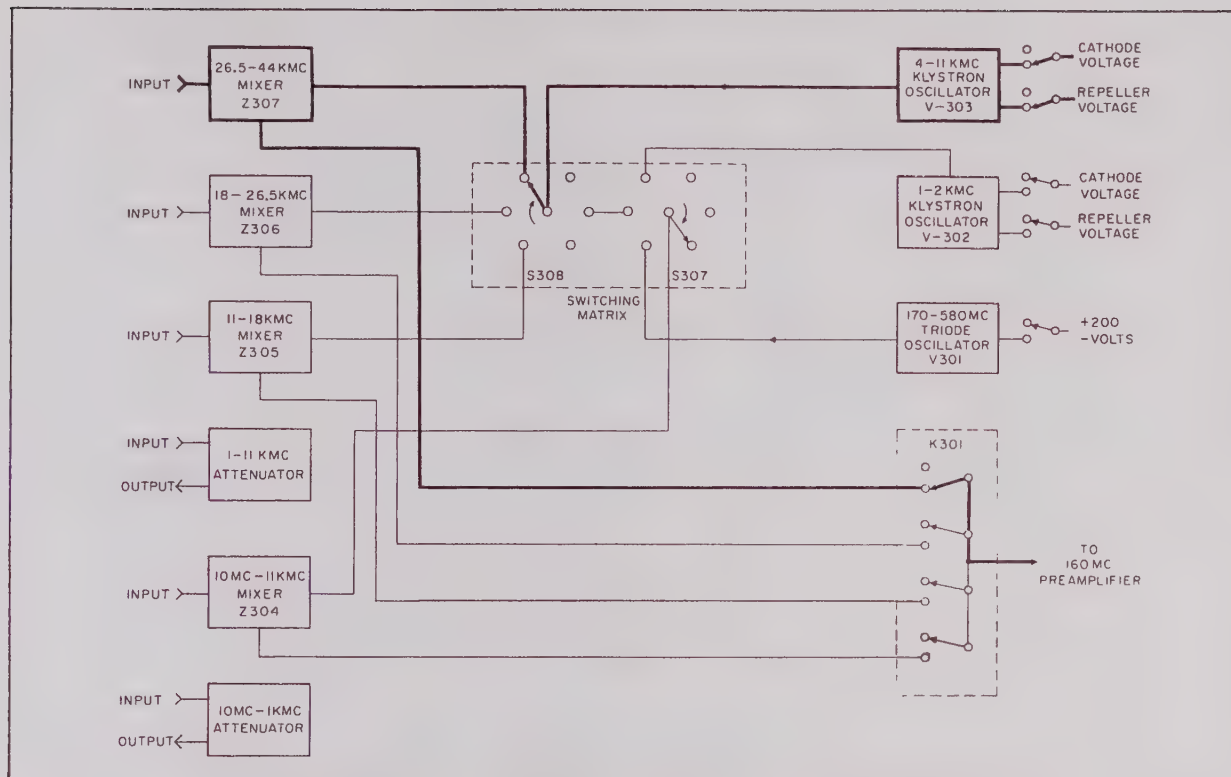


Figure IV-8. Block Diagram of Composite Tuning Head, RF-4a (Range 8).

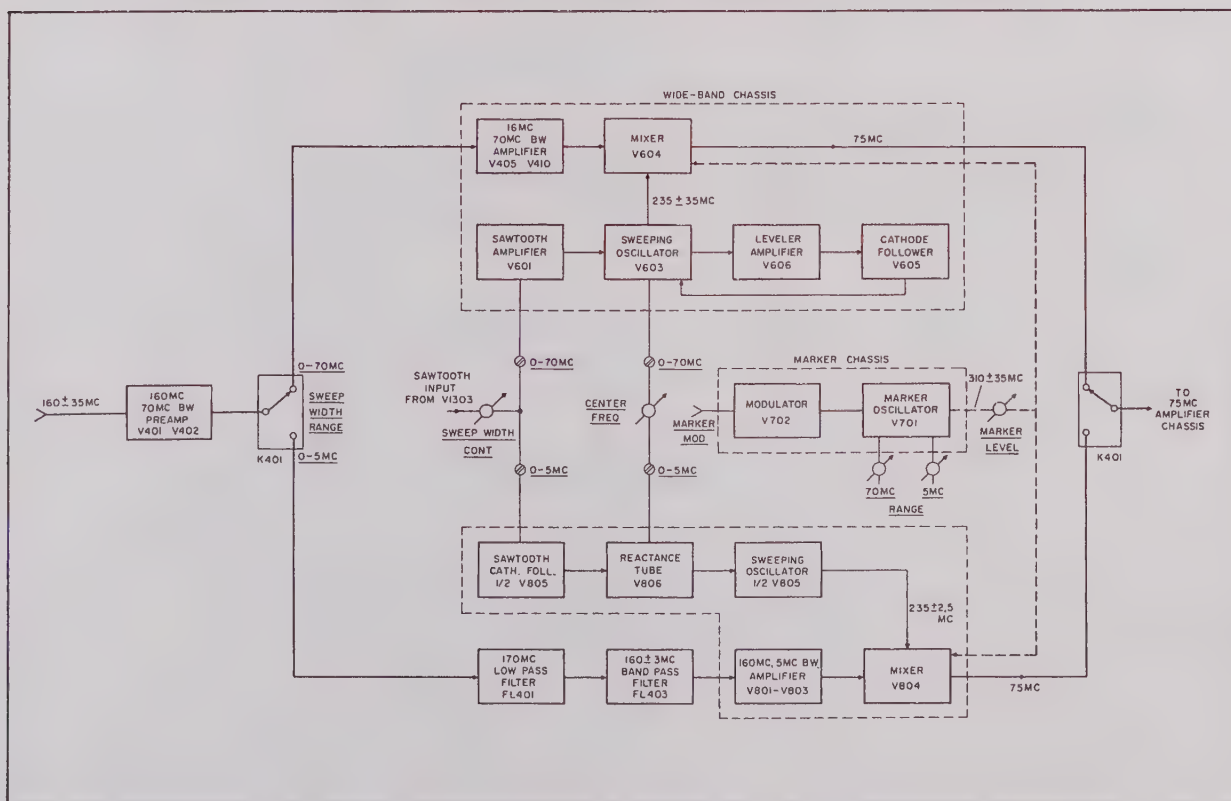


Figure IV-9a. Block Diagram of Indicator Unit, Model I-4a.

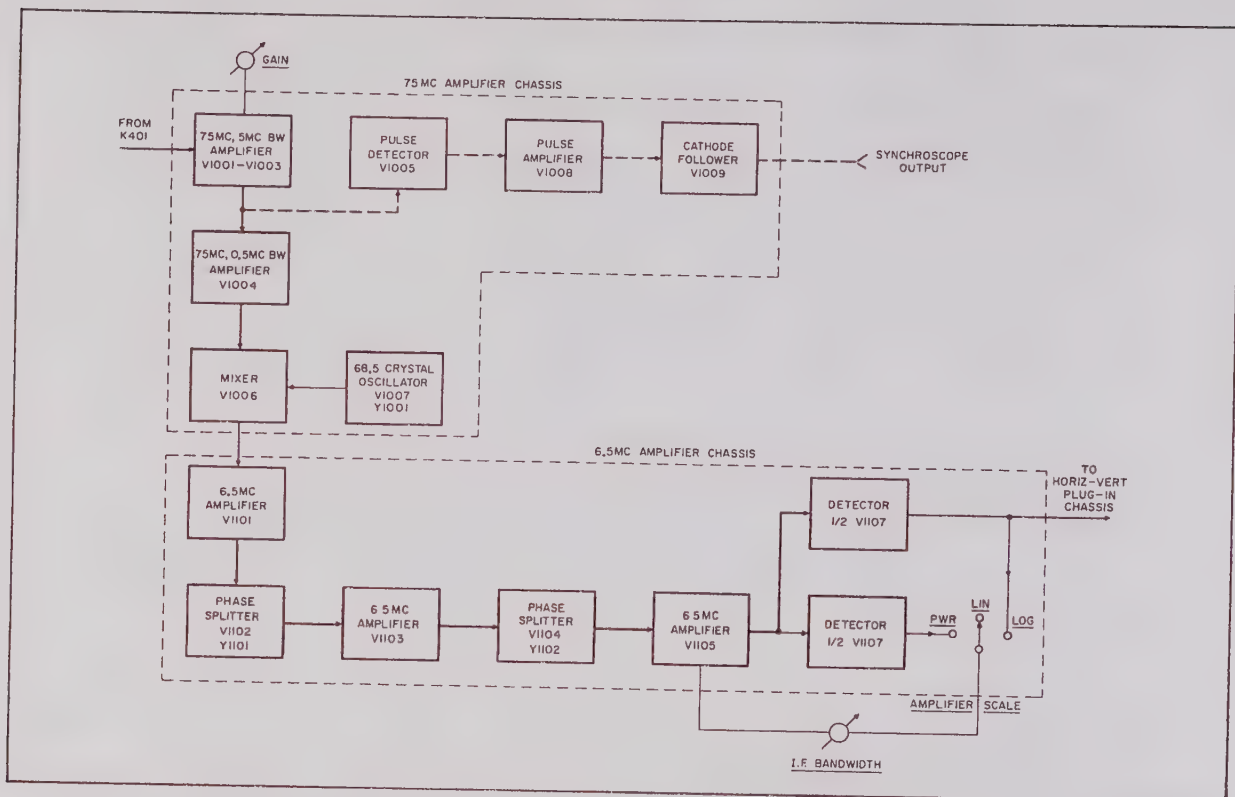


Figure IV -9b. Block Diagram of Indicator Unit, Model I-4a.

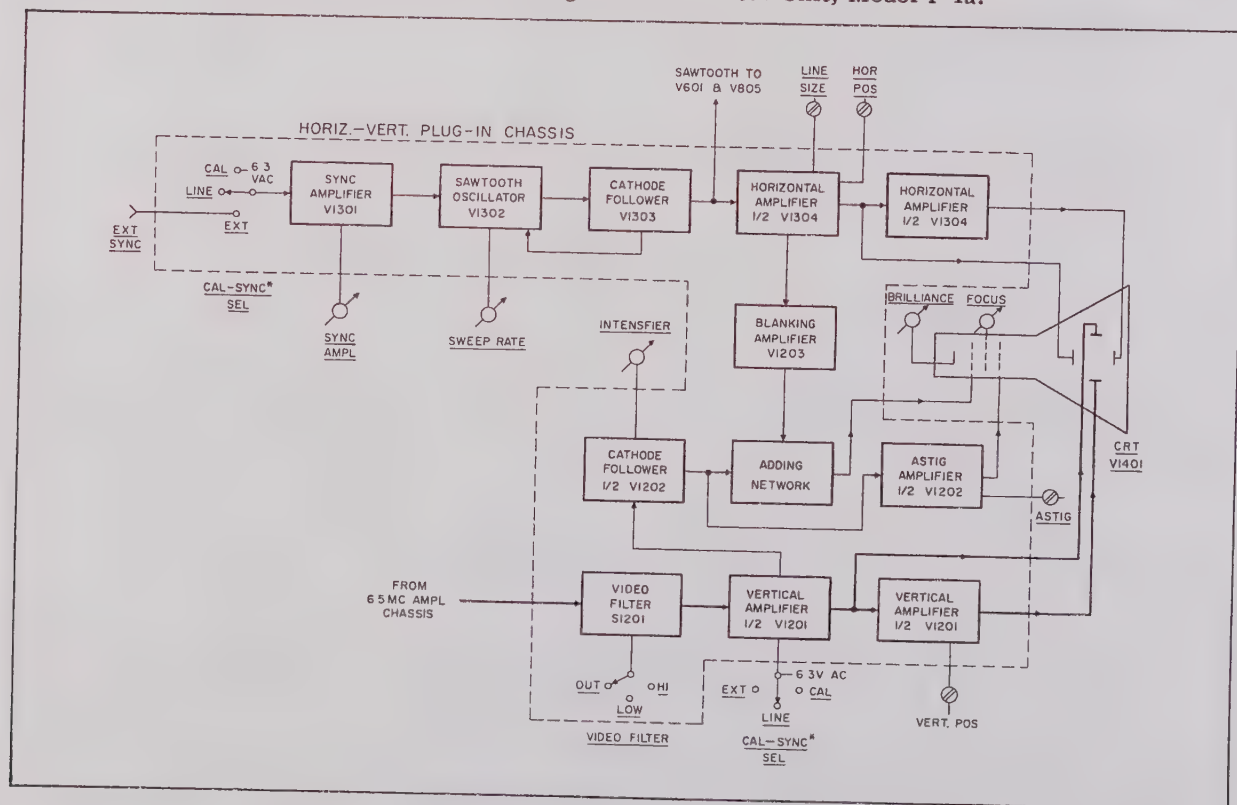


Figure IV -9c. Block Diagram of Indicator Unit, Model I-4a.

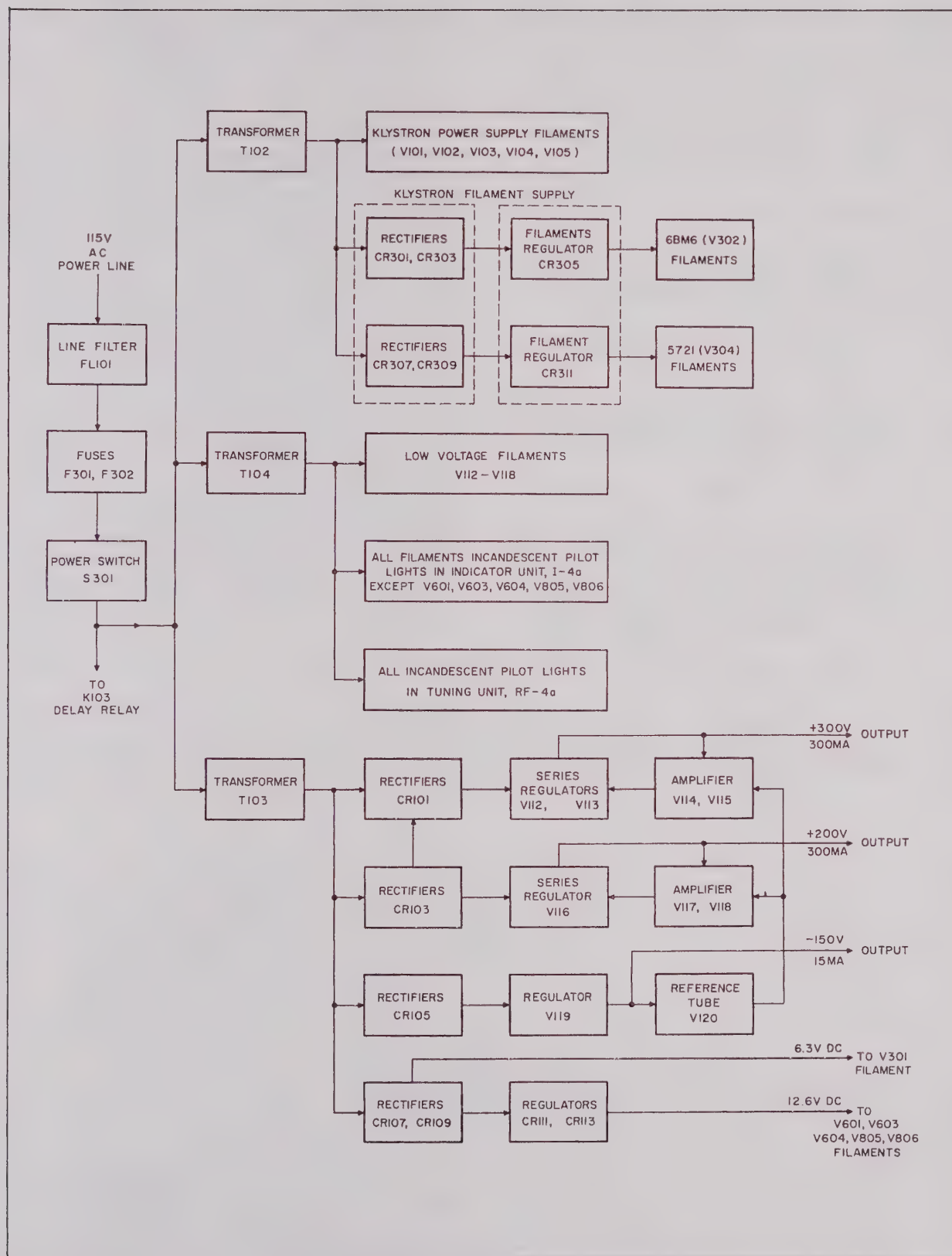


Figure IV-10. Block Diagram of SPA-4a Low Voltage and Filament Power Supplies.

degree of this intensification may be controlled by the intensifier control potentiometer R1249. The blanking amplifier receives a sawtooth signal from the horizontal sweep generator, differentiates it to produce a pulse during the sweep retrace time, and amplifies this pulse in V1203 to produce a negative pulse which is applied to the control grid of the cathode-ray tube.

IV-4. POWER SUPPLY

Block diagrams of the power supplies are given in Figs. IV-10 and IV-11. The schematic circuit diagram drawing number is P6-15225-3/3.

a. LOW-VOLTAGE POWER SUPPLIES. (Fig. IV-10).

The low-voltage supplies are conventional electronically regulated types supplying voltages of -150 volts, +200 volts and +300 volts.

b. CRT SUPPLY. (Fig. IV-13)

The high voltage for the cathode-ray tube is produced by an R-F type of power supply. Tube V121 acts as a power oscillator at a frequency of approximately 100 KC. The output voltage from this oscillator is stepped up in the secondary winding of transformer T105, then rectified by

two half-wave rectifiers, V122 and V123, to produce +2400 volts and -2400 volts for the cathode-ray tube accelerator and cathode voltages.

c. KLYSTRON POWER SUPPLY. (Fig. IV-11)

The Klystron voltages are obtained in an electronically-regulated supply which is switched to produce the proper voltages required by the two different klystrons which are used as local oscillators. The rectifier voltage is taken through V103 and V104, which are the series regulator tubes. V105 is a two-stage control amplifier which adjust the grid voltage of the regulator tubes to maintain the output voltage constant. The two cathodes of the control amplifier are referenced to the voltages across the glow-discharge tubes V106 and V107. The positive terminal of the power supply is connected to ground, so that negative output voltages are produced. The over-all supply voltage is switched to the different voltages required by the two klystrons by changing the resistor in series with V106 and V107, thus changing the supply voltage necessary to maintain the discharge. The four regulator tubes furnish an additional low-current regulated voltage in series with the series regulator output, to supply an additional -600 volts for the klystron repellers. A simplified schematic of the klystron power supply switching is shown in Fig. IV-12.

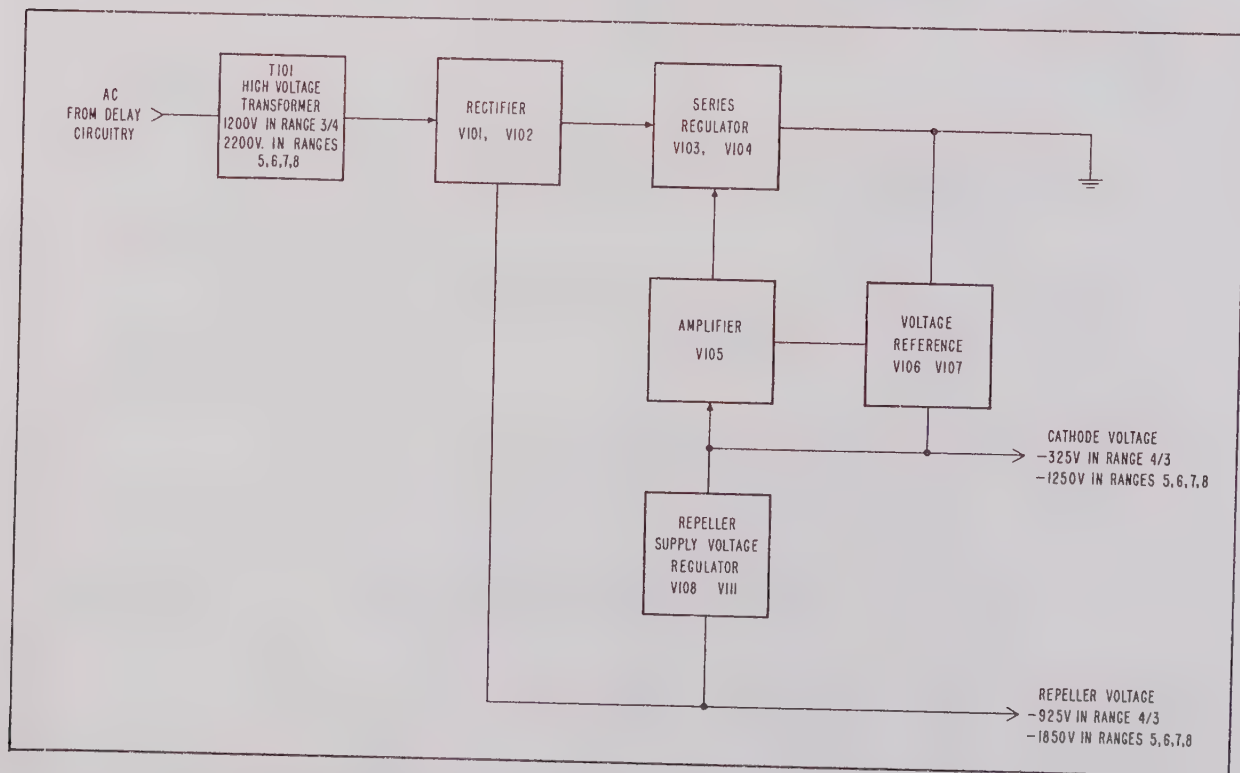


Figure IV-11. Block Diagram of Klystron Power Supply

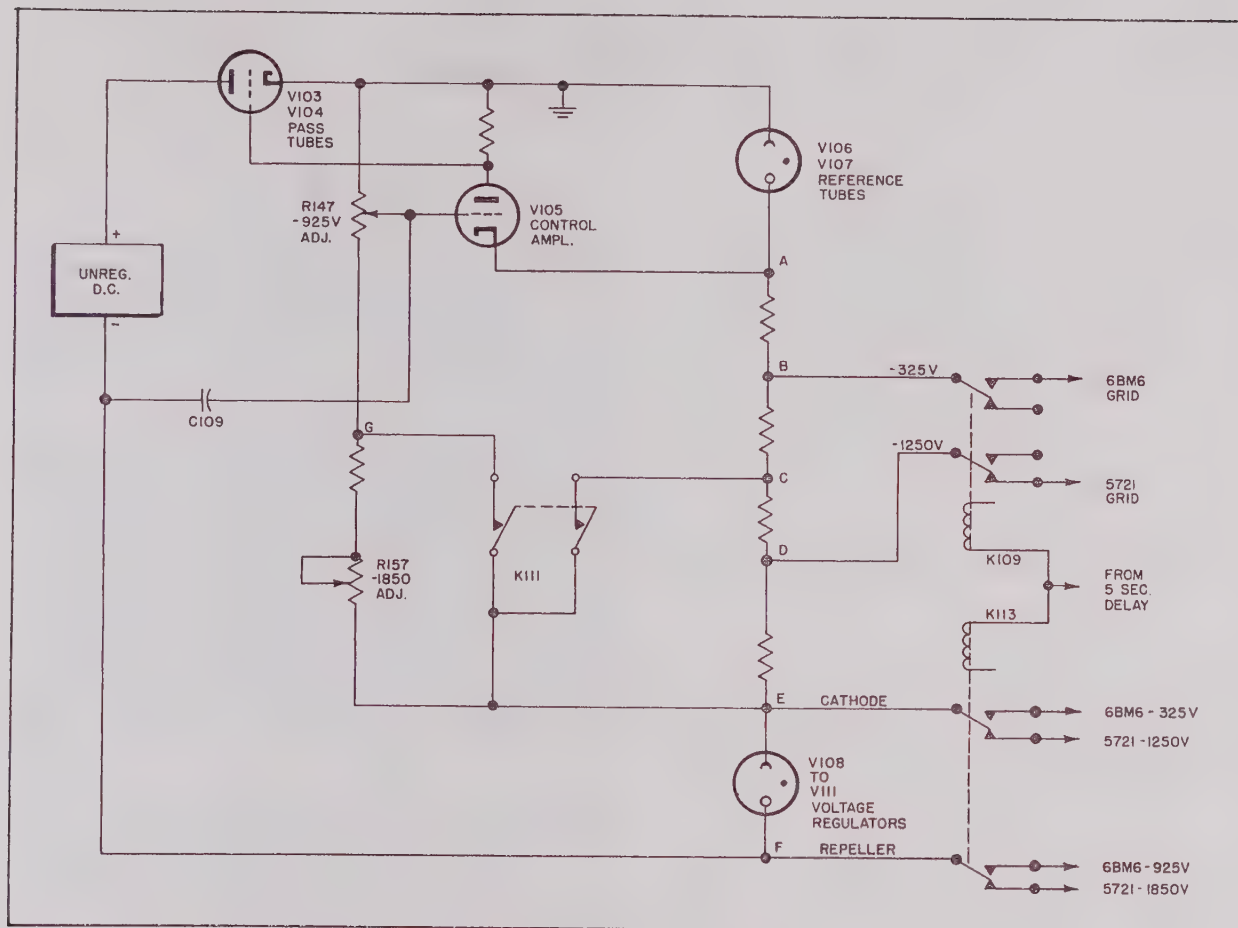


Figure IV-12. Klystron Voltage Switching.

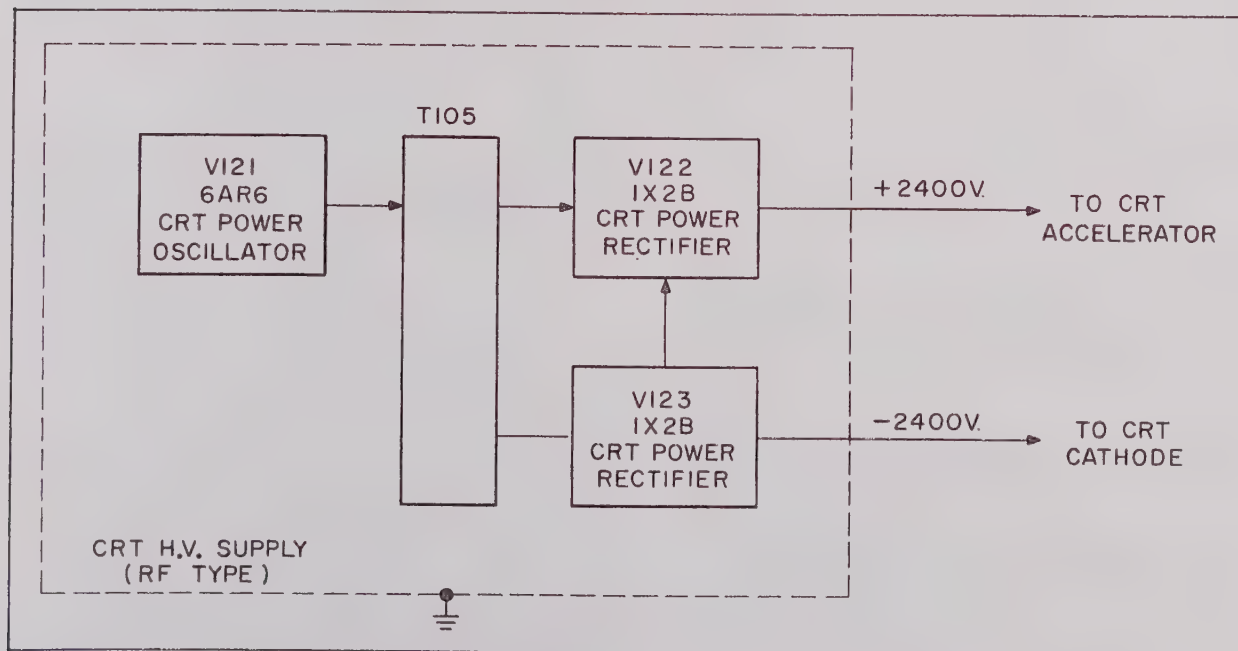


Figure IV-13. Block Diagram of CRT Power Supply.

CHAPTER V

SERVICE AND MAINTENANCE

INTRODUCTION

A complete realignment and recalibration of the Model SPA-4a requires a high degree of specialization in servicing instrumentation of this type and the use of specialized auxiliary test equipment.

The required specialized test equipment and personnel trained in its use are available in the Service Department of Singer Metrics Division, Singer Manufacturers & Company. If trouble develops which cannot be corrected by following the procedures outlined in the following paragraphs, it is recommended that the instrument be returned to Singer Metrics for servicing. Before returning the instrument, fill out the Repair and Maintenance Form bound in the rear of this Manual and send it to us. Upon receipt of this information our Service Department will send you service data or shipping instructions.

To expedite the return of the serviced equipment to you, it is recommended that the equipment be shipped to us by Air Freight and that we be authorized to return it the same way.

This chapter is divided into six sections to facilitate its use in connection with adjustment, repair or alignment of the equipment.

LIST OF RECOMMENDED TEST EQUIPMENT

Multimeter, Triplet Model 630 or equivalent
VTVM, RCA, Model WV98B or equivalent
Oscilloscope, Dumont 401 or equivalent
Signal Generator, Hewlett-Packard,
Model 608D or equivalent
Signal Generator, Hewlett-Packard,
Model 614A or equivalent
Signal Generator, Hewlett-Packard,
Model 618B or equivalent
Signal Generator, Hewlett-Packard,
Model 620A or equivalent
Signal Generator, Hewlett-Packard,
Model 624 or equivalent
Signal Generator, Hewlett-Packard,
Model 626 or equivalent
Frequency Doubler Set - Hewlett-Packard
Model 938A or equivalent
Frequency Doubler Set - Hewlett-Packard
Model 940A or equivalent
Wavemeter, FXR, Model N410A or equivalent
Wavemeter, Polytechnic Research & Development,
Type 532 or equivalent

Wavemeter, Polytechnic Research & Development,
Type 533 or equivalent
Wavemeter, Polytechnic Research & Development,
Type 535 or equivalent
50 Ohm Termination, Microlab TN50M
Oscillator, Hewlett-Packard Model 200CD
or equivalent
Klystron Repeller Mode Modulator
Broadband Sweep Generator, Telonic,
Model HD-1A or equivalent

Section V-1 covers the screwdriver adjust controls found on the panel and chassis of the equipment.

Section V-2 is a troubleshooting chart.

Section V-3 is service, maintenance and alignment procedure for the Indicator, Model I-4a, which may become necessary because of aging, replacement or failure of any of the tubes or components used in the equipment.

Section V-4 contains the alignment procedure for the Composite Tuning Head, Model RF-4a.

Section V-5 contains voltage and resistance charts.

Section V-6 contains gain measurement charts.

Section V-7 contains cable replacement charts.

Section V-8 contains a List of Replaceable Parts.

V-1. SCREWDRIVER ADJUST CONTROLS

These controls are in circuits which seldom require adjustment. They are located on the various chassis. Refer to Paragraph I-7 for a description of front panel screwdriver adjust controls.

a. SCREWDRIVER ADJUSTMENTS AND CONTROLS, COMPOSITE TUNING HEAD, MODEL RF-4a. (See Fig. V-1).

The following controls are located on a bracket (Fig. V-1, Ref. 1) at the top of the Tuning Head just behind the front panel:

1. 6BM6 OSC. ADJ.
 - (a) 0.9 KMC - 1.43 KMC
 - (b) 1.45 KMC - 2.2 KMC

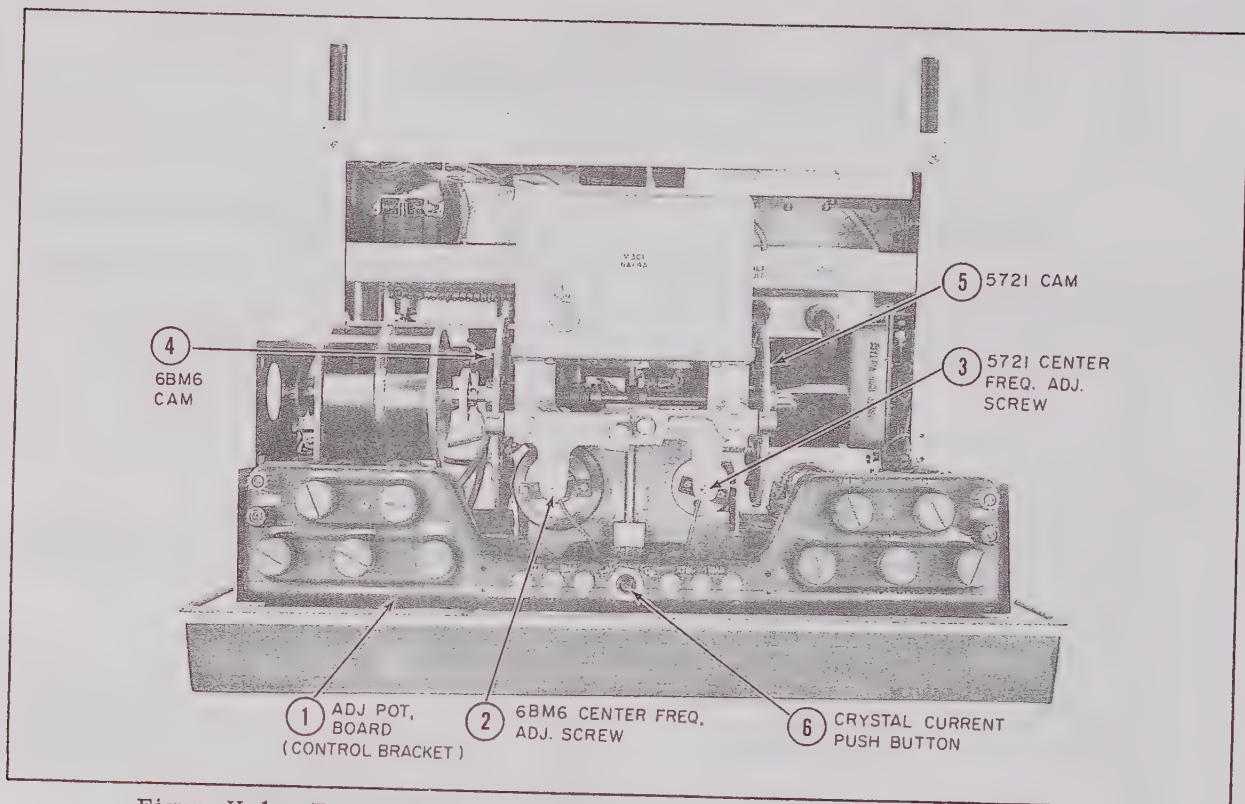


Figure V-1a. Top View of Composite Tuning Head, RF-4a (serial nos. 151-250).

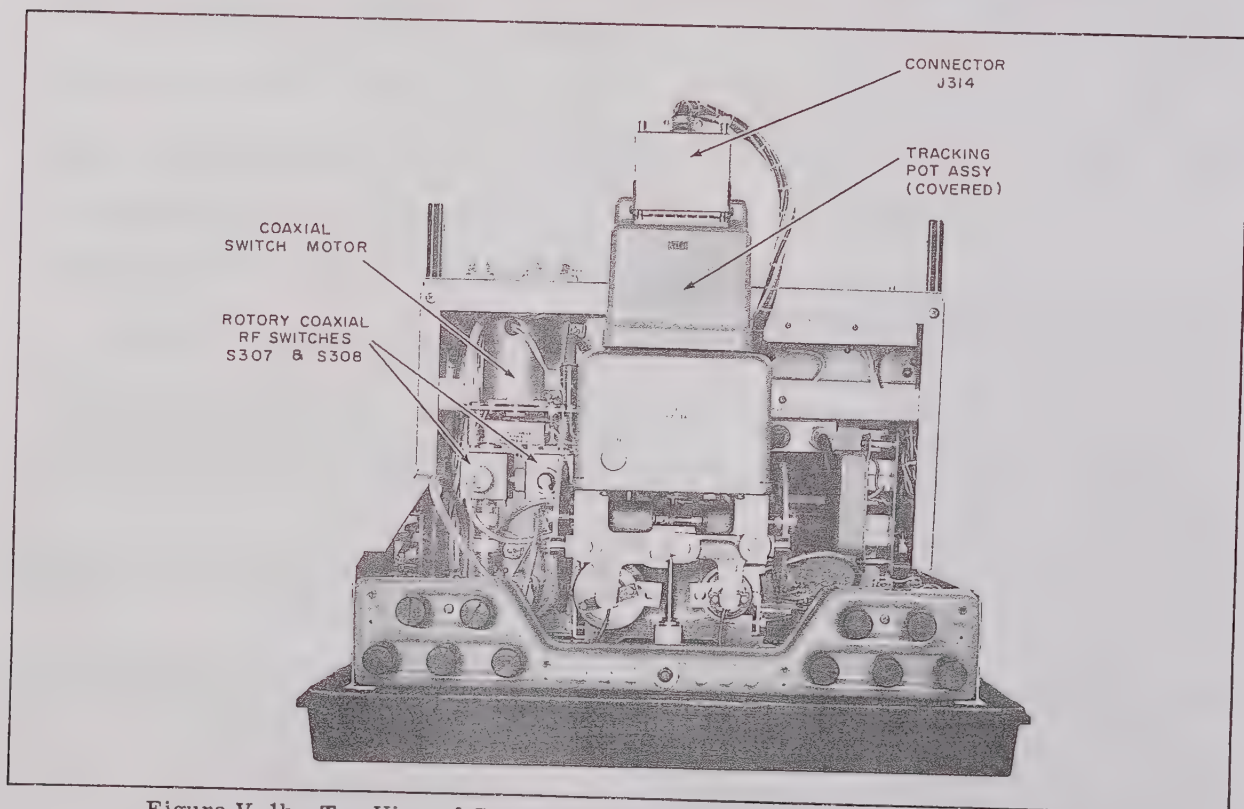


Figure V-1b. Top View of Composite Tuning Head, RF-4a (serial nos. 251-up).

2. 5721 OSC. ADJ.
 - (a) 4.4 KMC - 7.83 KMC
 - (b) 7.85 KMC - 10.9 KMC

These potentiometers adjust the repeller tracking voltages to keep the Klystron mode centered as the main tuning is varied. The designated frequencies are the nominal oscillator frequency points at which these potentiometers may be adjusted.

NOTE

These potentiometers should not be adjusted unless the Klystron mode plots are being viewed on an oscilloscope while following the procedure outlined in paragraph V-4.f.

3. 5721 OSC. ADJ., CURRENT
4. 6BM6 OSC. ADJ., CURRENT
(see NOTE)

These potentiometers control the beam current of the 6BM6 and the 5721 Klystrons respectively and are adjusted only during the alignment of the klystrons.

NOTE

On units bearing serial numbers 251 and up, the 6BM6 klystron operates on self bias. Therefore, the 6BM6 OSC. ADJ. CURRENT control should be set fully clockwise in order to obtain maximum grid return resistance (3 K ohms) at all times.

5. 6BM6 OSC. ADJ., MOD
6. 5721 OSC. ADJ., MOD

These are jacks to receive 60-cycle repeller modulation necessary for viewing the Klystron repeller mode plot on the screen of an oscilloscope.

7. XTAL BIAS, Range 1, 2 (10 MC - 1000 MC)
8. XTAL BIAS, Range 3, 4 (1 - 4.5 KMC)
9. XTAL BIAS, Range 5 (4.5 - 11 KMC)
10. XTAL BIAS, Range 6 (11 - 18 KMC)
11. XTAL BIAS, Range 7 (18 - 26.5 KMC)
12. XTAL BIAS, Range 8 (26.5 - 44 KMC)

These controls are used to vary the bias applied to the crystals of the r-f mixer(s). They

are set to an optimum point for each Range (paragraph V-4.g.).

13. G; 6BM6 Grid #1 test point
14. K; 6BM6 Cathode test point

These test points are used to check that the voltage on the 6BM6 Grid (to cathode) is set at not more than +1 volt during alignment.

15. G; 5721 Grid #1 test point
16. K; 5721 Cathode test point

These test points are used to check that the voltage on the 5721 grid to cathode bias is not more than +25 volts. The following controls are located on the various oscillator components:

17. Center Freq. Adj. Screw, 6BM6 Oscillator (Reference 2, Figure V-1)
18. Center Freq. Adj. Screw, 5721 Oscillator (Reference 3, Figure V-1)

These screws adjust the center frequency (freq. at "dead" spot on cam) for the Klystron oscillator.

19. Cam adjustments (5 adjustments on each cam). (See Fig. V-1, Ref. 4 and 5 also Fig. V-28). These provide for frequency adjustment in points of the cam off center frequency. There is, therefore, a 6 point frequency adjustment for each Klystron oscillator.
20. C309, C310, C311 (Fig. V-2 Ref. 1, 2, and 3). These are frequency alignment trimmers for the 6AF4 Triode Oscillator.
21. Triode Oscillator slider arm (Fig. V-2 Ref. 4 and 5). This is another frequency alignment device for the triode oscillator. This, plus the three capacitors, C309, C310 and C311, provides 4-point alignment for this oscillator.
22. XTAL CURRENT pushbutton (Fig. V-1, Ref. 6). When the METER FUNCTION switch is set to CRYSTAL BIAS and the XTAL CURRENT button S304 is depressed, it removes the bias and the meter reads true oscillator drive current.

NOTE

There are many oscillator points where the drive may be too weak to cause the

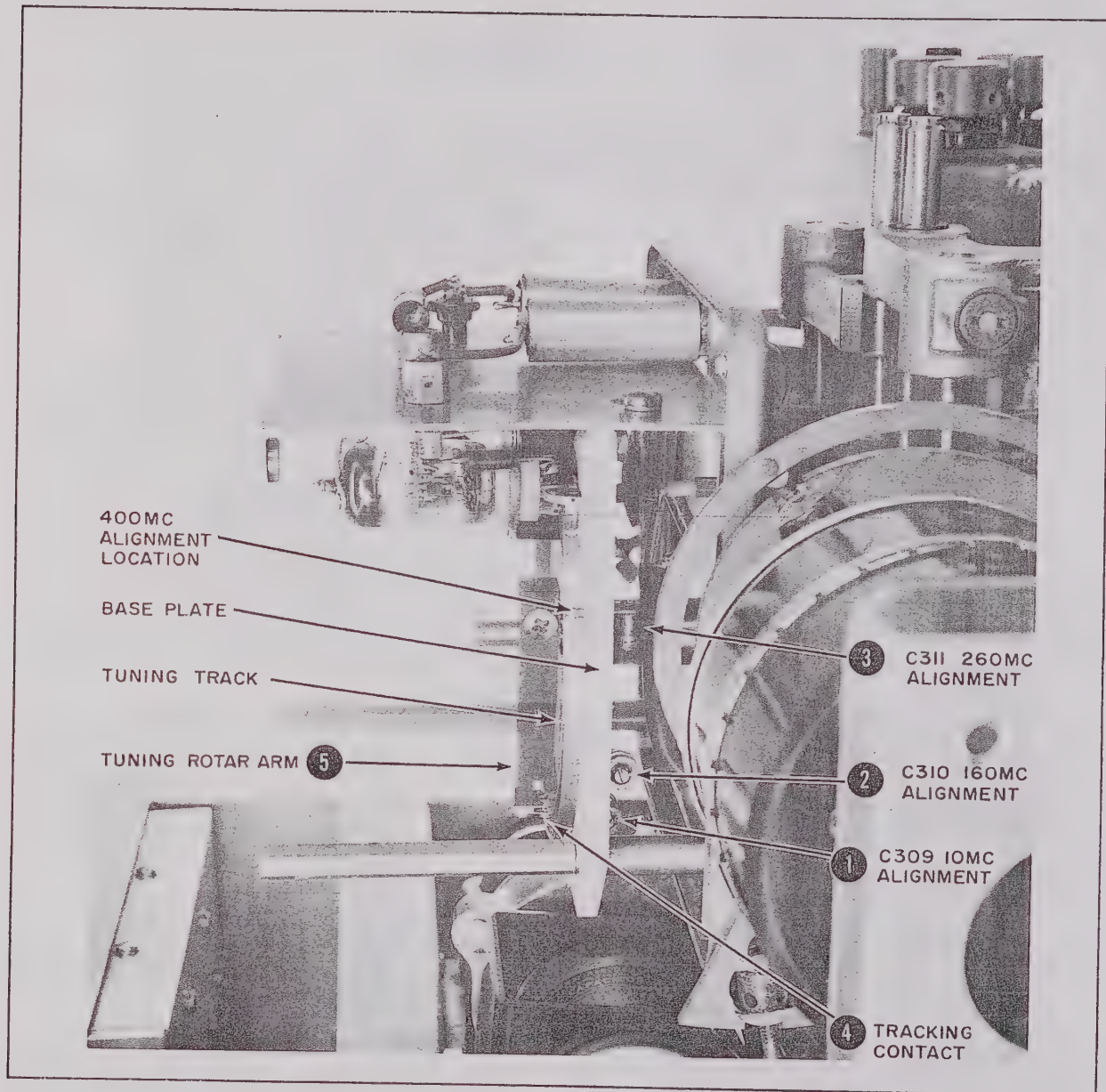


Figure V-2. Triode Oscillator with Cover Shield Removed.

meter to indicate, yet may be strong enough (in conjunction with the crystal bias) to operate the mixer properly. Therefore, an indication of no crystal current does not always mean that the oscillator is not operating properly.

b. SCREWDRIVER ADJUST CONTROLS, INDICATOR, MODEL I-4a. (See Figures V-3 and V-4).

The screwdriver adjust controls in the Indicator are located on various chassis. The wrap-around cover must be removed from the unit to

gain access to these controls. The controls are:

1. **CF LIN.** This control is located on the wideband i-f amplifier chassis, (Fig. V-3b, Ref. 1). It is used in conjunction with the front panel 70 MC SWEEP WIDTH screwdriver adjust control. Using the marker dial calibration as a reference, these two controls should be adjusted to give best linearity of the 70 MC sweep.

2. **OSC LEVEL.** This control is located on the wideband i-f chassis, (Fig. V-3b, Ref. 2). It is used to set the operating level of the 160 MC

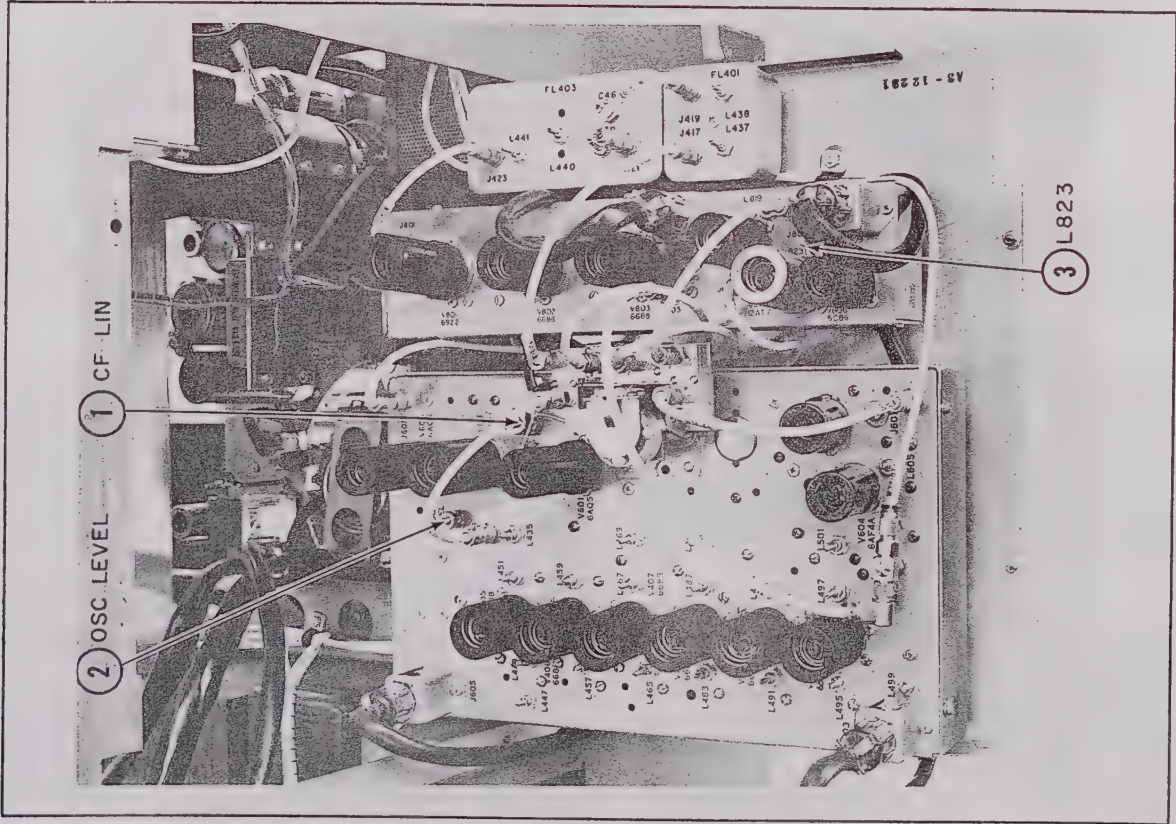


Figure V-3a. 160 MC IF Amplifier (Top View)
serial nos. 151-250.

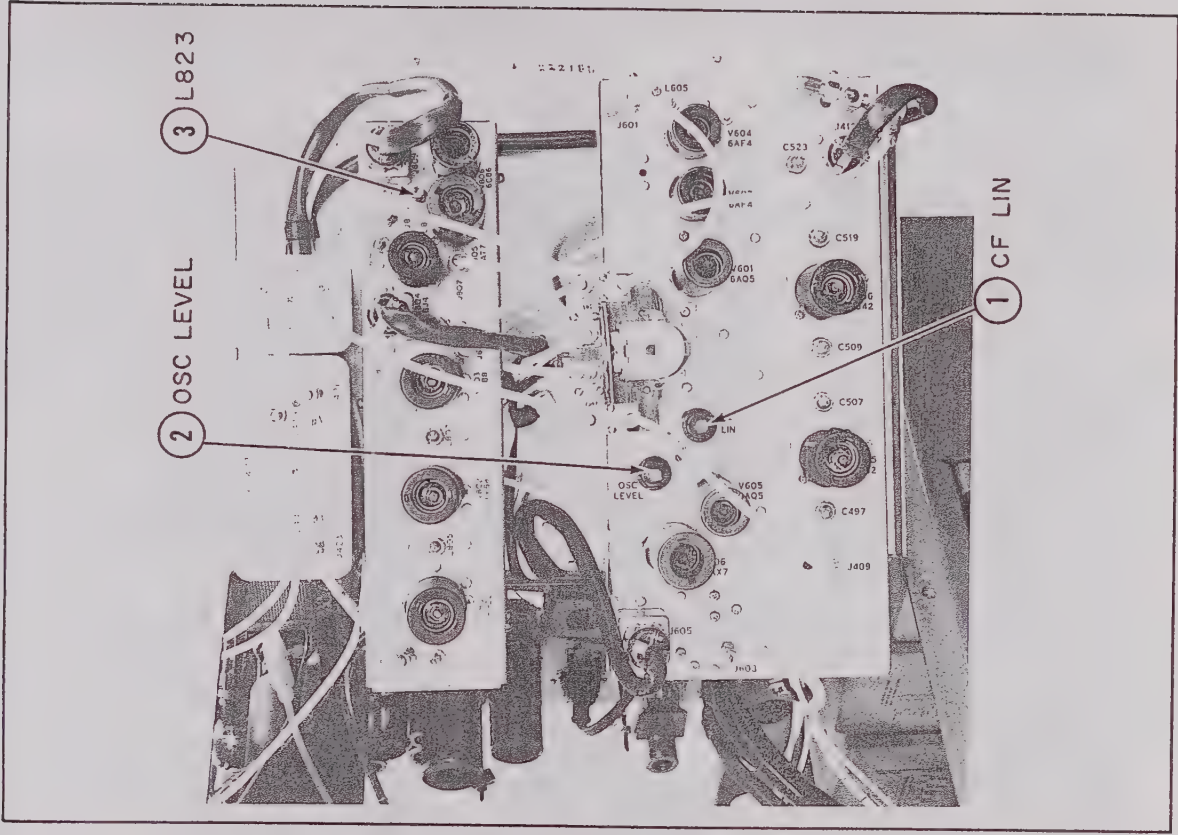


Figure V-3b. 160 MC IF Amplifier (Top View)
serial nos. 251-up.

It may be necessary to repeat the LOG ZERO and LOG -20 DB adjustments several times, since one control may affect the setting of the other.

7. **POWER SCALE ADJ.** This control is located on the 6.5 MC i-f amplifier. (Fig. V-4, Ref. 4) It is used to adjust the gain of the PWR position of the AMPLITUDE SCALE selector. With the IF BANDWIDTH control set to fully CW position and the AMPLITUDE SCALE set to PWR, obtain a full scale signal on the screen. Reduce the signal strength by 3 db. The height of the signal should drop to half scale. If it does not decrease the required amount, adjust the POWER SCALE pot until it does.

In addition to the above controls, there are a number of trimmer adjustments on the various chassis in the indicator. These are factory adjustments, and should not be changed in the field.

c. SCREWDRIVER ADJUST CONTROLS, POWER SUPPLY. (See Fig. V-5).

There are four screwdriver adjust controls in the power supply, located at the rear of the unit. The back cover must be removed from the unit to gain access to these controls. The controls are:

1. **+200 V ADJ, R211** (Fig. V-5, Ref. 1). This control adjusts the voltage of the +200 volt supply. It should be adjusted to make the voltage measured at junction of R209 and pin 5 of C127 exactly +200. (Fig. V-5, Ref. 2).

2. **+300 V ADJ, R187** (Fig. V-5, Ref. 3). This control adjusts the voltage of the +300 volt supply. It should be adjusted to make the voltage measured at junction of R185 and pin 3 of C127 exactly +300. (Fig. V-5, Ref. 4).

3. **-325 V ADJ, R147** (Fig. V-5, Ref. 6). This control adjusts the -325 volt supply to which the 6BM6 Klystron cathode is connected. Set the band switch to Range 2 to energize the 6BM6 klystron and adjust this control to make the voltage measured at pin 5 of V108, (Fig. V-5, Ref. 5) exactly -325.

4. **-1250 V ADJ., R157** (Fig. V-5, Ref. 7). This control adjusts the -1250 volt supply to which the 5721 Klystron cathode is connected. Since the -325 volt and the -1250 volt adjustments are not independent, the -1250 volt should be adjusted only after the -325 volt adjustment has been completed. Set the band switch to Range 3 to energize the 5721, Klystron and adjust the control to make the voltage measured at pin 5 of V108 (Fig. V-5, Ref. 5) exactly -1250.

V-2. TROUBLESHOOTING

WARNING

When servicing the equipment, be extremely careful of the exposed high voltages. Discharge capacitors before doing any testing. With the high voltage off, potentials of more than 2,000 volts are still present in the analyzer and the power supply.

a. Most of the parts in the analyzer are readily accessible and may be replaced easily if found to be faulty. If the SWEEP WIDTH RANGE switch requires replacement, mark the wires connected to the switch with tags to insure proper connections when the new switch is installed. Follow this practice whenever replacement requires the disconnection of numerous wires.

b. When a part is replaced in any RF or IF circuit, it must be placed exactly in the same position as the original part. A part which has the same electrical value but different physical size may cause trouble in high-frequency circuits. Pay particular attention to proper grounding when replacing a part. Failure to observe these precautions may result in decreased gain or the possibility of oscillation in the circuit.

c. **SELF-CHECKING FEATURES.** The Model SPA-4a contains built-in self-checking features which can be used in the event of failure to help localize the source of trouble. When an input signal is applied and does not appear on the screen, the following procedure can be used for basic troubleshooting of the equipment.

1. Switch the front panel meter to the +200 and +300 volt positions to check that the power supply is functioning properly. Half scale deflection should be obtained in either position. (Refer to Table I-4).

2. Turn up the marker amplitude to obtain a marker pip on the screen. If a normal marker is obtained, then the trouble is in the circuits before the 160 MC mixer stage. If a normal marker cannot be obtained, try both wide and narrow-band sweeps. If it can be obtained in one and not in the other, the source of the trouble is in the IF amplifier which does not produce a normal marker.

3. If a normal marker cannot be obtained for either wide or narrow-band sweeps, then the trouble is in the analyzer section beyond the 160 MC IF amplifier, or in the marker oscillator. If there is grass on the screen, the amplifiers are operating properly and the marker or the sweep circuits may be defective. If there is no grass, one of the amplifiers is defective.

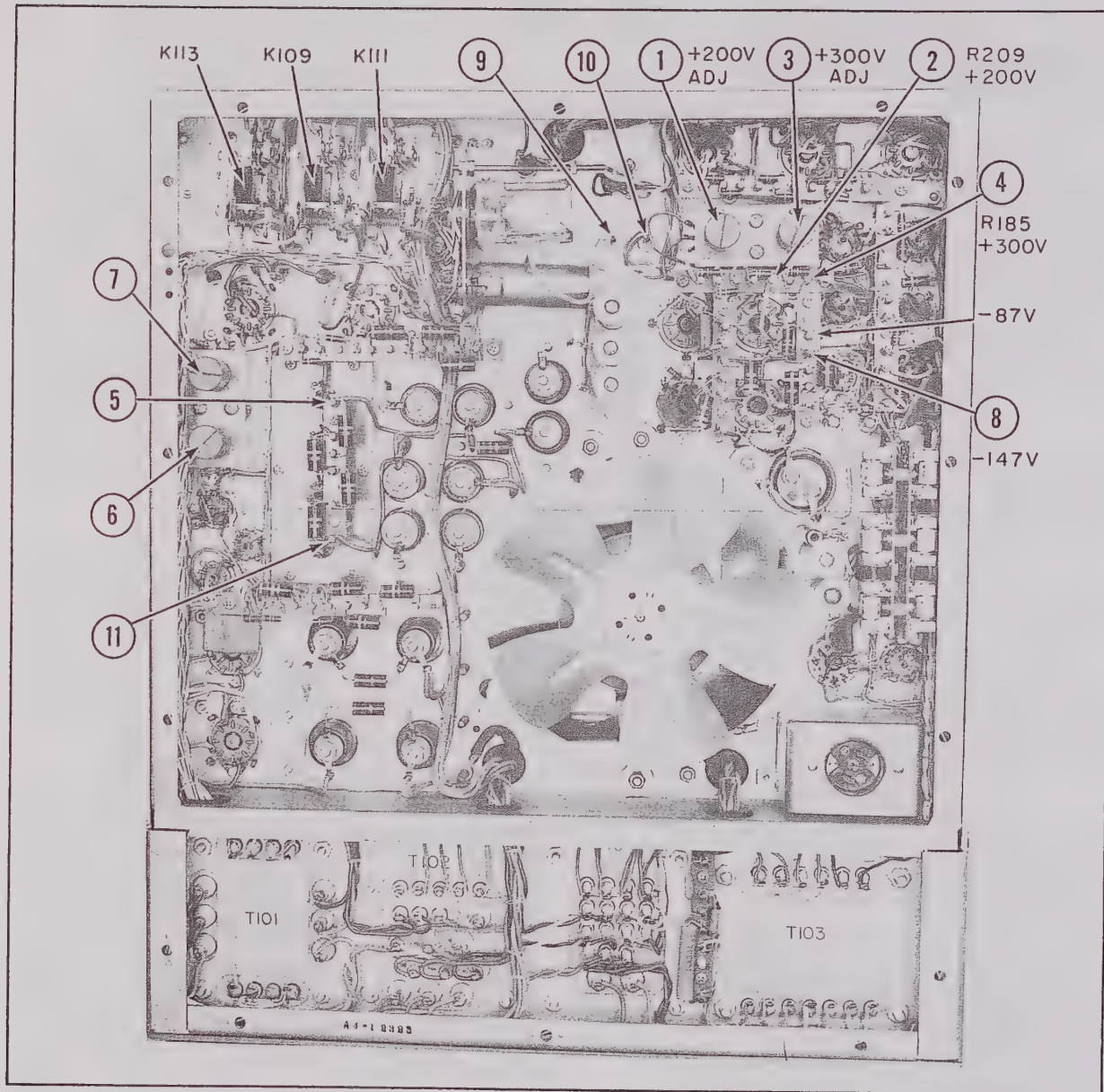


Figure V-5. Power Supplies (Rear View).

4. If the marker can be obtained on the screen, remove the input cable and switch the meter to read crystal bias. If no meter reading is obtained on any band when the various band-selector push-buttons are depressed, pull the Tuning Head forward from the case on its slides and depress the XTAL CURRENT switch on the center of the crystal bias pot bracket. If there are no meter readings in any range, then there is a defect in the crystal bias or current return circuit.

5. If crystal bias and current are obtained on some bands, but not the one that is to be used,

the trouble may be a defective crystal or in the local oscillator. Tune across the dial and observe the crystal current reading over the entire band, since the tuning may have been set to a frequency of low local oscillator drive. Also check the current return circuit for that band.

6. The operation of the 1-2 KMC and the 4-11 KMC local oscillators can be checked by the front panel meter. In the KLYSTRON CURRENT position, the meter indicates the current flowing through the tube. The reading should be between 0.5 and 0.7 on the meter scale. If there is no Klystron current, switch to CATHODE V

and REPELLER V to check the cathode and repeller voltages. Readings should be approximately half scale. If voltages are normal and there is no Klystron current, check the Klystron wiring and connectors. If these are correct, then the Klystron is defective and must be replaced. If voltages are low, check the klystron power supply and associated relay switches for poor contact.

7. If the Klystrons are operating normally, check all the local oscillator signal leads from the Klystron output probe to the local oscillator input connector on the mixer. Also examine the probe itself to check that the solder connections on the 50-ohm resistor have not broken loose. Check the coax switching. Note that the same local oscillator (5721) is used for the upper four frequency ranges, therefore, if one or more

of these ranges is operating properly the failure is not likely to be in the Klystron.

d. TROUBLE SHOOTING CHART.

The Table V-1 is supplied as an aid in locating trouble in the analyzer and power supply. The Table lists the symptoms which the repairman observes while making a few simple tests. The Table also indicates how to localize trouble quickly to a circuit stage or circuit element. Once the trouble has been localized to a stage or circuit, a tube check, voltage and resistance measurements of this stage or circuit should ordinarily be sufficient to isolate the defective part or parts. Normal voltage and resistance measurements are given in Section V-5, Voltage and Resistance Charts.

TABLE V-1, TROUBLESHOOTING

SYMPTOM	PROBABLE TROUBLE	CORRECTION
1. No illumination on the screen when POWER switch is turned to the ON position. Pilot lamp does not light.	AC power is not being supplied to the power supply or the indicator.	Check interconnecting cables. Check for input voltage.
	Open fuse F301 or F302 in power supply.	Replace fuse. If it blows again, check power supply.
	Transformer defective.	Check transformer output voltages.
2. No illumination is observed on the screen of CRT. Pilot lamp lights.	Improper adjustment of BRILLIANCE or FOCUS controls. Improper adjustment or HORIZONTAL POSITION or VERT. POSITION controls.	Adjust these controls.
	Failure of B+ or crt high-voltage supply.	Remove high-voltage lead to CRT and measure voltage. Remove the crt high-voltage power supply from its cage and compare voltages measured between each terminal and the chassis with values shown in paragraph V-5 (Voltage and Resistance Chart).
	Defective CRT.	Replace CRT.
3. With the GAIN control turned completely counterclockwise, a dot or short line is observed on the screen but a horizontal baseline (horizontal sweep) is not obtained.	Faulty sweep stage.	Check tubes V1301 to V1304 and their tube socket resistances and voltages.

SYMPTOM	PROBABLE TROUBLE	CORRECTION
	E1301 (NE-16) defective DS1301 (TS51) defective Improper adjustment of LINE SIZE control.	A P-P sawtooth of at least 50 V should appear at pin 4, J1301. Adjust this control. Use the procedure given in Par. II-3.
4. HORIZONTAL POSITION control does not center the baseline trace.	Tube V1304 or its circuitry is defective.	Check tube and the tube socket voltages and resistances.
5. With the SWEEP WIDTH control set at its maximum clockwise position, the vertical deflection (representing a signal or marker) does not appear as a peak, but rather as a shift in the baseline.	Defective sweep oscillator driver 160 MC i-f amplifier. SWEEP WIDTH control R1361A or R1361B misadjusted or defective. Inductor L601 defective. Sweep oscillator stage is defective.	Check tubes V601 (i-f 0-70 MC sweep) or V805-806 (i-f 0-5 MC sweep). Check the tube socket voltages and resistances. Rotate control to its maximum clockwise position. Check this control for open or shorts and replace if necessary. Check and replace if necessary. V603, V604, V606 or V805 V806, V804 tube and replace if necessary. Note: Replacement of any of these components requires the realignment of the corresponding i-f strip.
6. Inability to obtain full sweep frequency range.	Incorrect setting of SWEEP WIDTH limit potentiometer. Defective variable inductor L601, oscillator V603 or V806, phantastron V1302, sweeper drive V1303. V601 or V805.	Readjust potentiometer R1365 (0-5 MC SWEEP) or R1363 (0-70 MC SWEEP). Check and replace if necessary.
7. GAIN control turned completely counterclockwise, the horizontal baseline is obtained, but is unstable in CAL and SYNC positions of the CAL-SYNC SEL switch.	Horizontal oscillator circuit not synchronized. Faulty sweep stage.	Adjust the SYNC AMP control. Use the procedure given in paragraph II-3.d. Check tubes V1301 - V1303 and E1301, DS1301, and the voltages and resistances for the tube sockets.

SYMPTOM	PROBABLE TROUBLE	CORRECTION
8. Horizontal baseline trace appears normal, but no vertical deflection signal or noise is observed when the GAIN control is turned in a clockwise direction.	Defective tube(s) in 6.5 MC or video amplifier stages. VIDEO FILTER switch shorted to ground.	Check V1101 - 1107. V1201-1203. Check to see that VIDEO FILTER switch shaft has not twisted askew.
9. The tops of the pips on the screen of the CRT flatten off below full-scale deflection.	Tube V1201 or its circuitry is defective.	Check tube and the tube socket voltages and resistances.
10. The VERT POSITION control does not line up the baseline with the frequency scale.	Tube V1201 or its circuitry is defective.	Check tube and the tube socket voltages and resistances.
11. The amplitude of the signals on the screen is low with the GAIN control of the indicator turned clockwise until .2 of full scale of screen noise is present.	Input signals of very low magnitude, or improper connections of the r-f signals. Defective i-f stage. Improper adjustment of the IF GAIN control. Improper alignment of the indicator tuning circuits.	Check the input signals and the RF cables. Check tubes in 160 MC, 75 MC, and 6.5 MC IF amplifiers. Check the tube socket voltages and resistances. Adjust this control. Use the procedure given in paragraph V-1.b.2. Realign the indicator. Use the procedure given in paragraphs V-3a, b, c, and d.
12. No marker but r-f signal appears on screen.	Marker oscillator inoperative. Cable W39-07 defective.	Check the marker oscillator. Check voltages at tube V701 & V702. Replace tube or defective components.
13. With the SWEEP WIDTH control turned completely clockwise, the vertical deflection representing a 0 MC marker signal does not appear on the horizontal baseline at the zero line of the calibrated scale.	Improper adjustment of the CENTER FREQ adjust potentiometers R635 or R855, the CENTER FREQ control, or the MARKER LEVEL control.	Adjust these controls. Use the procedures given in paragraph II-3.f and g.
14. The CENTER FREQ control does not center signal when the scanning width is reduced.	Varistor RV601 is defective (0-70 MC sweep). Tubes V601, V805 or V806 or their circuitry defective.	Check and replace if necessary. See V & R chart. (V601) Check and repair if necessary.

SYMPTOM	PROBABLE TROUBLE	CORRECTION
	CF ADJ potentiometer R635 (0-70 MC sweep) misaligned or defective.	Realign this control. Use the procedure given in paragraph II-2.g.
15. The frequency scanning is non-linear.	CF LIN adjustment R621 set incorrectly. (0-70 MC) L819 and/or L823 adjustment set incorrectly. (0-5 MC)	Adjust this control. Use procedure given in paragraph II-3.g.
	Defective V601, L601 or circuitry. (0-70 MC)	Check tube. Check tube socket voltages and resistances.
	Defective V805 or V806 or circuitry.	Check tube. Check tube socket voltages and resistances.
16. The screen of the CRT contains burned spots or "permanently" etched signal traces.	Defective CRT.	Turn CAL-SYNC SEL switch to CAL. Turn SYNC control fully counterclockwise and SWEEP RATE control to give a fast random sweep across screen. Turn GAIN, BRILLIANCE, and FOCUS controls fully clockwise so that screen is flooded. Leave CRT this way for 5 or 6 hours. If the traces are not washed away at the end of this period, replace the CRT.
17. The screen of the CRT has high brilliance at all positions of the BRILLIANCE control.	CRT faulty.	Replace CRT V401.
	R1409 or C1405 defective.	Check and replace if necessary.
18. The AMPLITUDE SCALE calibration is inaccurate.	Tubes V1106 or V1107 defective.	Check tube and the tube socket voltages and resistances.
	LOG -20 DB ADJUST and LOG ZERO ADJUST controls are misaligned.	Realign controls. Use the procedure given in paragraph V-1.b.5 and 6.
	PWR control misaligned.	Realign control. See par. V-1b,7.
19. Resolution is unsatisfactory with the SWEEP WIDTH CONT set for a broad pip with I-F BANDWIDTH control fully CW as evidenced by an asymmetrical pip, and/or appearance of a rejection slot.	Tube V1102 or V1104 is defective.	Check and replace if necessary.
	Coils L1101 or L1103 or capacitor C1119 or C1135 misaligned or defective.	Realign coils and capacitors. Use the procedure given in paragraph V-3.b.5.

SYMPTOM	PROBABLE TROUBLE	CORRECTION
	IF BANDWIDTH control R1125 A/B or crystal Y1101 or Y1102 defective.	Check and replace if necessary.
20. Low noise level when GAIN control is set at maximum. Signal appears when applied.	The IF GAIN control R1111 is misadjusted or defective. Low gain in analyzer.	Reset this control for 1/2 or fullscale noise on 0-70 MC sweep. (See 20.b) (a) If marker amplitude is normal, examine wide-band and narrow-band 160 MC i-f amplifiers for defective tubes or components. (b) If marker amplitude is low, examine 75 MC IF, 6.5 MC i-f, and video amplifiers for defective tubes or components.
21. Low noise level and no signal.	68.5 MC oscillator in 75 MC i-f chassis not operating. Defective narrow- or wide-band 160 MC i-f amplifier, sweeper or sweeper drive circuits, 235 MC sweeper. Sweeper drive.	Check adjustment of L1013. Check V1007 and circuitry. Check for presence of normal marker amplitude. If the marker does not appear, the trouble is in the sweeper or the sweeper drive. Check for presence of sawtooth at jack J603 or J807. If sawtooth is present, check the 235 MC sweeper circuit. (Sawtooth voltage at pin 4, J1301 should be a minimum of 50V P-P). If sawtooth is present, check the sweeper drive circuit, V601, or V805.
22. Varying amplitude (greater than ± 3 DB) of a signal that is tuned across the length of the horizontal baseline. (Narrow or Wide Band operation)	Defective tube in 160 MC i-f amplifier. (Narrow or Wide Band or Pre-Amplifier)	Check all tubes in amplifier. Check the socket voltages and resistances. CAUTION: Do not adjust slugs unless prepared to perform a complete realignment.
23. (a) Low signal to noise ratio. (b) Signals do not track across entire range (Range 3-8)	(a) Defective crystal mixer in RF tuner. (b) Incorrect Klystron anode voltage (Ranges 3 to 8). Weak klystron.	(a) Replace crystal. (Refer to table for operational check. (b) Readjust anode voltage control tube V105 or voltage. Check Klystron power supply.

SYMPTOM	PROBABLE TROUBLE	CORRECTION
(c) Signals do not track across entire range (Range 1 & 2) (See Item 25)	(c) Tuning arm of Triode oscillator loose or dirt on tracks.	(c) Clean triode tracks with approved solvent and cotton swab.
24. Noise normal but no signal.	(a) Defective crystal mixer in r-f tuning unit. (b) Crystal bias potentiometer misadjusted. (c) No local oscillator output. (d) Range co-ax switch S307, S308 not tracking. Selector co-ax relay, K301 making poor or no contact.	(a) Replace crystal. (b) Check crystal biasing circuit. (c) Press CRYSTAL CURRENT button and read panel meter on CRYSTAL BIAS point. Needle should deflect even minutely off zero. If there is no deflection, check local oscillator circuit. Replace defective tubes or other components. (d) Continuity check circuitry. Refer to paragraph V-4.k.
25. No r-f sensitivity for portions of the tuning range (dead spots). Range 3 to 8. (See item 23)	Local oscillator Klystron tube in r-f tuning unit defective. Klystron tracking voltage off alignment.	Check Klystron r-f power output by observing modes. Refer to paragraphs V-4.e.4 (Range 3/4) and V-4.f.4 (Ranges 5 to 8). Check repeller voltage supply at jack J311 or J315 and refer to the repeller tracking procedure for the r-f tuning unit. See paragraph V-4.e.4 and f.4.
26. The indicator operates normally except that some vertical peaks are present along the baseline which do not move as the frequency of the external signal generator is varied.	Electrical interference, the frequency of which is synchronized with the sweep frequency of the indicator.	In many cases, the trouble may be traced to a nearby electrical appliance connected to the same power source as the Indicator, or the trouble may be in the power source. Corrective power filters may be used in the event that the interference is caused by appliances. If the power source is the cause and a motor generator set is being used, corrective filters should be used.
27. (a) Signal "breakup". (Unusually high incidental fm on Marker pip only) NOTE: 1. More than 2000 cps on Narrow-Band Marker. No external signal.	Excessive ripple or oscillations in +200 or +300 volt power supply.	With no external signal, use the MARKER as the applied signal and measure the incidental fm. Check +200 and +300 volt supplies for ripple (Normal ripple approx. 5 mv, should not exceed 10 mv)

SYMPTOM	PROBABLE TROUBLE	CORRECTION
2. More than 25 kc on Wide-Band Marker. No external signal. (b) Signal "break-up" on Bands 3 - 8 unusually high incidental fm on external signal. Marker pip o.k. WARNING: It is advisable to first determine that the breakup is not caused by the characteristics of the external signal. If possible, compare signals from several sources.	1. Defective variable inductor L601, defective tubes V603, 604 in Wide-Band Amplifier. 2. Defective tubes V804, 805 or 806 in Narrow-Band Amplifier. Excessive ripple in klystron power supply Klystron tube defective or microphonic. Intermittant or poor contact in co-ax switches (S307, S308, K301, K401)	Check tubes for microphonic tendencies. It may be necessary to realign sweep circuits when changing these tubes. Refer to par. V-3d. Check klystron power supply. Refer to par. V-4.c. Dirty contacts on all or any voltage relay. Check operation of klystron tube. Refer to par. V-4. Continuity check these switches. Refer to paragraph V-4.k.
28. Hum on baseline.	Low voltage power supply.	Check voltage and ripple of the +200 volt and +300 volt outputs. When replacing V112 and V113, these tubes must both be replaced at the same time. (They should be replaced with a matched pair.)
29. Overheating.	Dirty air filter. Defective fan B101.	Clean filter. Replace fan.

V-3. SERVICE, MAINTENANCE AND ALIGNMENT PROCEDURE, INDICATOR UNIT, MODEL I-4a

This section indicates adjustments which may become necessary because of aging, replacement, or failure of any of the tubes or components used in the Indicator, Model I-4a.

a. GENERAL.

All tunable coils and transformers are tuned by means of movable iron cores. Windings at the top and bottom of the coil are tuned with a hollow iron core which may be turned with the hex end of the aligning tool supplied with the equipment. The bottom windings may be tuned from either the top or bottom of the transformer. When the bottom coil is approached from the

top, the tool is inserted through the top hollow core and finally engaged in a slot in the top of the lower core. Variable glass trimmer capacitors are located in the triode oscillator pre-amplifier and wide-band amplifier chassis. Alignment tools (Walsco #2519, 2541, #2543) are supplied with the SPA-4a. Allow the Model SPA-4a and necessary signal generators to warm up for at least one-half hour before alignment is attempted.

The tuning and alignment procedures which follow are presented as being traced from the output to the input of the signal circuits so that later sections in the circuit may be used in aligning the preceding sections. Optimum values are given, but some slight readjustment may be required to achieve optimum performance. Retuning instructions given in the alignment procedures

refer to this, and mean that only a slight re-touching of the adjustment is necessary.

As the tuning proceeds from stage to stage, unless otherwise stated, it will be necessary to reduce the signal input voltage in order to maintain the deflection on the cathode-ray tube screen below 3/4-full scale with at least 1/32" of noise on baseline to insure against overloading the final stages.

NOTE

It is advisable to use "cheater" power cables and/or signal input and output cables for all sub-chassis during servicing. They should be 4 to 6 feet long and the cable wires be connected to corresponding pins in mating male and female connectors. The following procedures are based on the use of "cheater" cables.

Although the Panoramic Spectrum Analyzer, Model SPA-4a will operate satisfactorily in the line voltage range from 105 Vac to 125 vac, the information regarding alignments, adjustments and checks given in this chapter require that line voltage be set at 115 vac at all times.

In the following procedures internal cables are disconnected from their normal locations and re-connected in special test configurations. References in the text to cable numbers (w-numbers) apply to only one serial number series. For specific instruments, refer to Paragraph V-7, CABLE REPLACEMENT CHARTS, as an aid in determining the appropriate cables to be changed.

1. The frequencies involved in the alignment procedure are as follows:

Unit	Center Frequency	Bandwidth
Wide-band IF Amplifier	160 MC	70 MC
Narrow-band IF Amplifier	160 MC	5 MC
75 MC IF Amplifier	75 MC	4 MC
6.5 MC IF Amplifier	6.5 MC	1 to 80 KC continuously variable

2. Set the front panel controls as follows:

SWEEP WIDTH CONT Fully clockwise
 SWEEP WIDTH RANGE As indicated in procedure
 SWEEP RATE 20 or 30 CPS

CAL-SYNC SEL. LINE
 GAIN To give 1/2 to 3/4 full scale signal deflection
 AMPLITUDE SCALE LIN
 IF BANDWIDTH Fully clockwise
 VIDEO FILTER OUT
 INTENSIFIER Fully counter-clockwise
 BRILLIANCE Brightness as desired
 FOCUS For sharp trace
 CENTER FREQ To center zero marker pip on screen
 MARKER LEVEL To give adequate deflection on screen
 MARKER FREQ Zero

b. LOW-VOLTAGE POWER SUPPLY (Fig. V-5).

All measurements are made to chassis ground unless otherwise stated. All measurements are made with the power supplies fully loaded by the various sub-chassis. Disconnecting a sub-chassis in case of its being short-circuited will not seriously affect the servicing information given below.

The dummy load, shown in figure V-38, can be used in place of the various sub-chassis loads.

CAUTION

If the dummy load is to be used, all interconnecting power cables must be removed from the sub-chassis before turning power ON. Refer to Voltage and Resistance Chart of Low Voltage Power Supply for help in performing any necessary checks.

1. +300, +200, -150 Volt Supplies.

(a) Turn POWER ON with push-button switch in Range 1 position. Check to see that VR tubes V119 and V120 are lit.

(b) Connect voltmeter to +300 V line at Ref. Point (4) Fig. V-5. Adjust R187 (+300 V ADJ) to bring voltage to +300 volts. Ripple on a calibrated scope should be less than 5 mv.

(c) Connect voltmeter to +200 V line at Ref. Point (2) Fig. V-5. Adjust R211

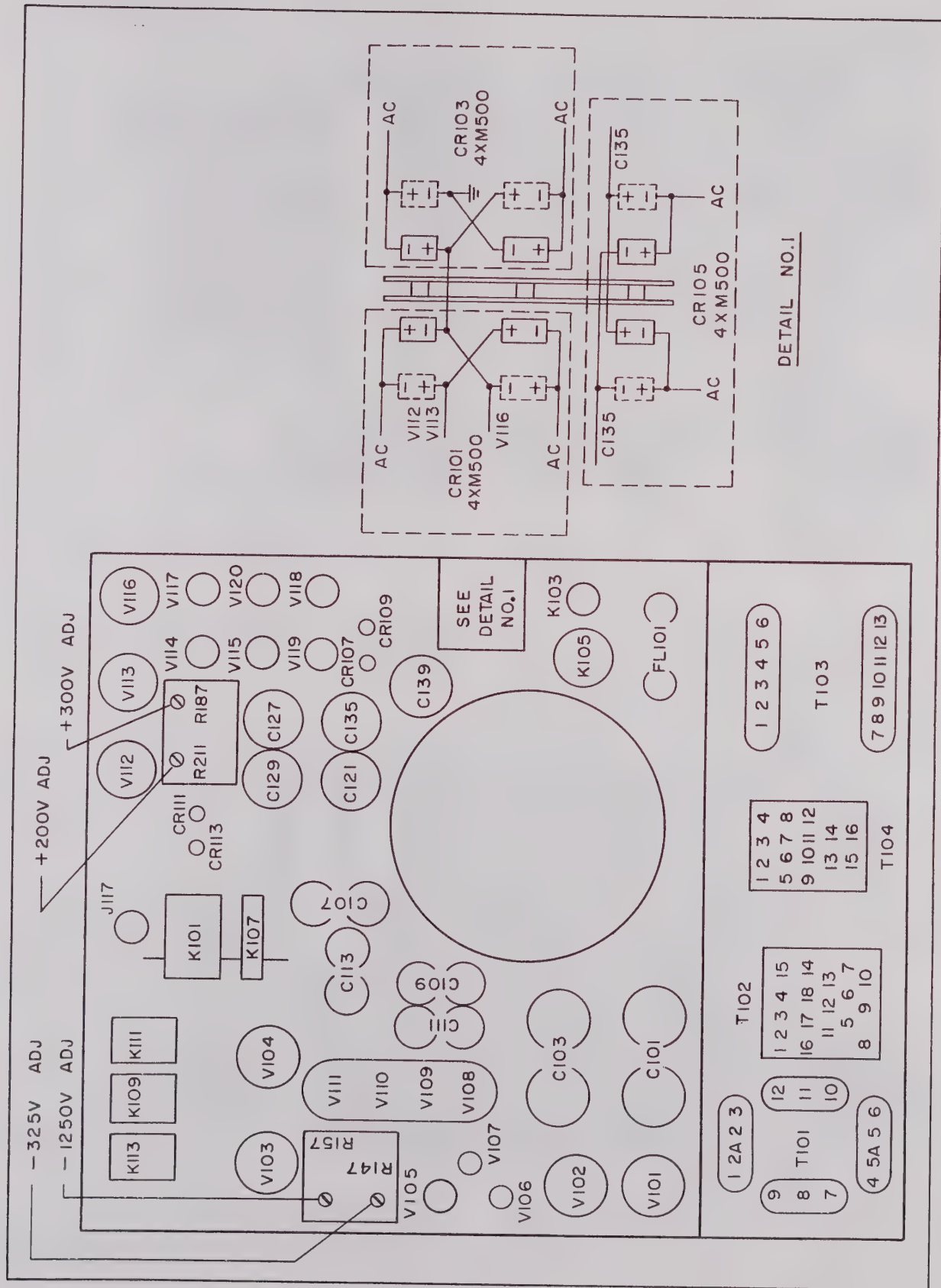


Figure V-6. Component Layout (Power Supply).

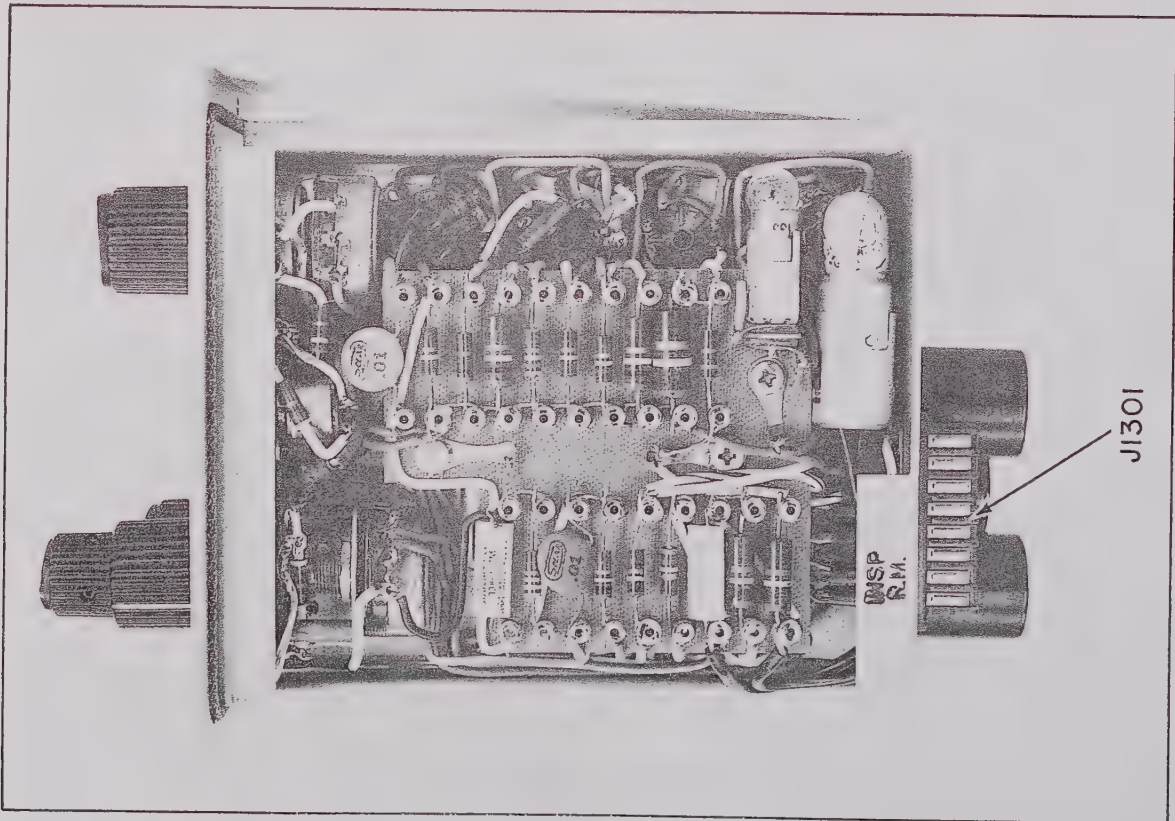


Figure V-7a. Sweep Generator (Hor. & Vert. Ampl)
Top View

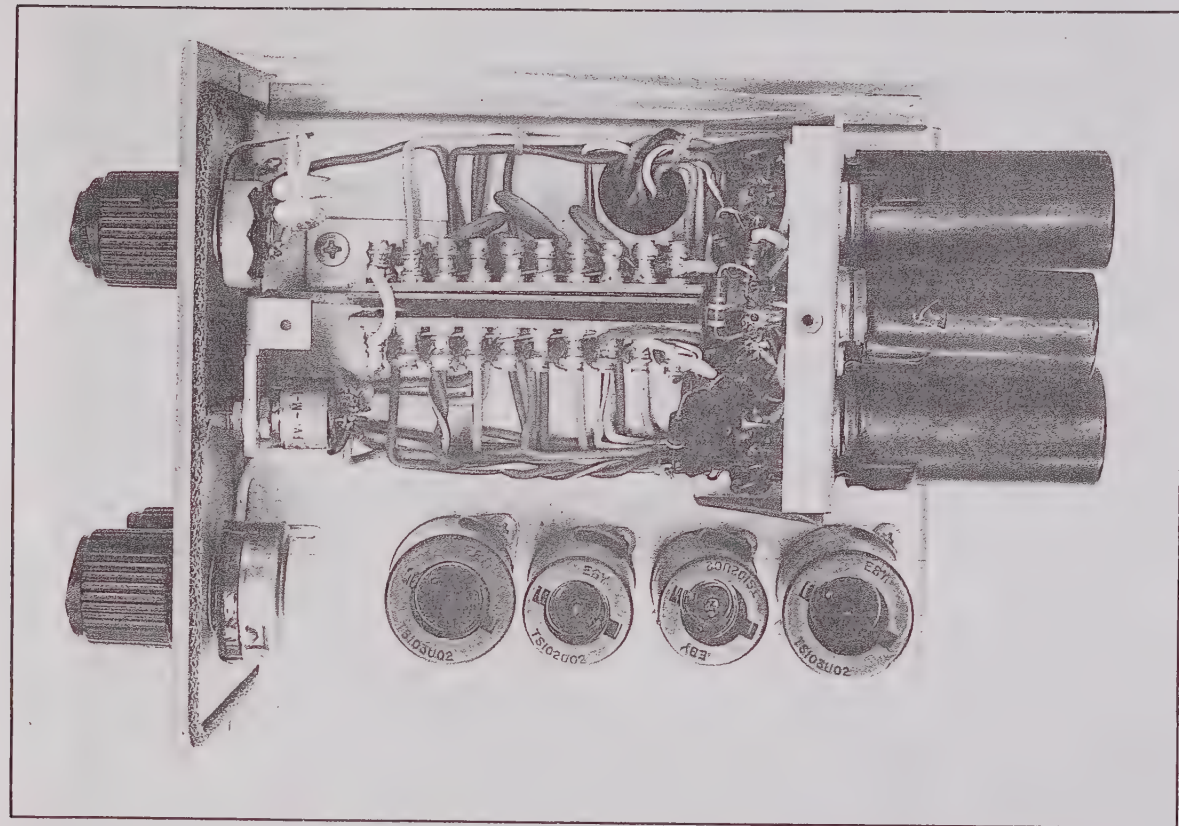


Figure V-7b. Sweep Generator (Hor. & Vert. Ampl)
Bottom View

(± 200 V ADJ) to bring voltage to +200 volts. Ripple on a calibrated scope should be less than 5 mv.

(d) Connect voltmeter to -150 V line at Ref. Point (8) Fig. V-5. It should read approximately -145 volts. Ripple on a calibrated scope should be less than 3 mv.

2. 12.6 Volt Filament Line. (Test Points 9 & 10) Fig. V-5.

(a) Connect a voltmeter to CR111. Voltage should be approximately -12.6 V. Ripple at 115 VAC line should be less than 150 mv.

(b) Connect a voltmeter to CR113. Voltage should be approximately -12.6 V. Ripple at 115 VAC line should be less than 300 mv.

c. KLYSTRON POWER SUPPLY

WARNING

High voltages are present in this area.
Use appropriate safety precautions.

Delay and Selector Relays. (Fig. V-6). Turn POWER switch to OFF position for approximately 1 minute. Depress RANGE button 4/3 and turn power ON.

(a) Within 60 seconds ± 10 sec. delay relay K103 will close and activate holding relay K105 and H.V. bleeder selector relay K111. At the same time, K101, the primary winding selector switch for T101 will be energized and will connect the proper taps for the -925 V output.

(b) In an additional 5 seconds ± 2 secs. delay relay K107 will close and activate the voltage selector relays K109 (klystron grid) and K113 (klystron repeller and cathode). These voltages are automatically fed to the proper klystron (5721 or 6BM6) through the cabling design.

(c) When RANGE #5 button is depressed, all the selector relays K101, K109, K111 and K113 are deenergized.

(d) When the RANGE buttons are in STANDBY position (all out), the A.C. line voltage is disconnected from the high voltage transformer T101.

(e) The RANGE buttons, in all positions except STANDBY and 2/1, supply a +200V screen bias to V103 and V104 (6146, the high voltage pass tubes) through S302E.

NOTE

An indication of a low output in either voltage or current on the front panel meter may be caused by dirty or corroded contact points on the delay and/or selector relays.

d. SWEEP GENERATOR AND HORIZONTAL AMPLIFIER. (Fig. V-7).

Remove the horizontal sweep sub-chassis from analyzer. Connect a "cheater" extension cable between J1301 and P1301. Check to see that pilot bulb (DS1301) is lit. The test scope should be well synced to 60 cycles. LINE SIZE control fully clockwise. Connect scope vertical input lead to pin 5 - J1301.

1. SWEEP RATE.

(a) Set CAL-SYNC SEL to LINE position. Turn SWEEP RATE and SYNC AMP controls fully counterclockwise.

(b) Count the rate of scope deflection; it should be less than 10 counts in 10 seconds. Turn the SWEEP RATE control fully clockwise; the rate of deflection should increase to more than 60 cps.

(c) If the sweep rate generator does not have the 1-60 cps range stated above, the most likely source of trouble will be the neon bulb, type NE-16. Replace this with a pretested bulb that will fire at 60 vac or less. It should be painted with a conductive paint in a similar fashion to the original. The paint acts as a capacitive pick-up for the 60 cycle sync voltage.

2. SYNC AMP.

(a) Set SYNC AMP control fully CCW. Connect scope lead to pin 5 - J1301.

(b) Turn the SWEEP RATE control until a 60 cycle output is obtained. Detune slightly until the signal is slightly off 60 cycles and moves slowly across the screen.

(c) Slowly turn the SYNC AMP control CW until the signal locks in. This should occur at approximately 1/2 turn.

3. EXT SYNC.

(a) Connect scope lead to pin 5 - J1301. Turn CAL-SYNC SEL to EXT position. SYNC AMP control fully counterclockwise.

(b) Connect an audio oscillator to the EXT SYNC jack on front panel. Adjust the oscillator to give 3 volt rms output at 60 ± 1 cycles.

(c) Turn the SYNC AMP control clockwise approximately 1/2 turn. The signal on both the scope and CRT screen should lock in.

4. LINE SIZE.

(a) Connect scope lead to pin 4 - J1301.

(b) The sawtooth voltage should measure between 45 V and 60 V p-p. (A higher reading is preferable).

(c) Reconnect scope lead to pin 5 - J1301.

(d) Rotate LINE SIZE control slowly clockwise. The amplitude should vary between 50 V and 150 V p-p.

(e) Connect the scope lead to pin 3 - J1301.

(f) Rotate LINE SIZE control slowly clockwise. The amplitude should vary between 70 V and 180 V p-p.

5. H POS

(a) Connect the scope lead to pin 5 - J1301.

(b) Slowly turn the H POS control counterclockwise. The sawtooth signal should clip at the top. Adjust the control at approximately center of travel. The sawtooth should become undistorted. Signal level is approximately 130 V p-p.

(c) Connect the scope lead to pin 13 - J1301.

(d) Slowly turn the H POS control clockwise. The sawtooth signal should clip at the bottom. At approximately the center of rotation the sawtooth should be undistorted and measure about 180 V p-p.

e. VERTICAL (VIDEO) AMPLIFIER.

1. Vertical Gain.

(a) Connect audio oscillator to pin 16 - J1301. Connect scope lead to pin 15 - J1301. Set CAL-SYNC-SEL switch to LINE position.

(b) Adjust the oscillator to 600 cycles at 1.25 V p-p output. An undistorted output of 30-40 V p-p should appear on the screen.

2. V POS.

(a) With the same set-up as above, except for moving the scope input to pin 8 - J1301, proceed to the following step.

(b) Turn the V POS control slowly clockwise. The signal output should change in amplitude from a distorted signal approximately 3 V p-p to a maximum of approximately 45 V p-p to a minimum of 5 V p-p.

NOTE

When positioning the baseline vertically, always adjust from full clockwise position.

3. CAL position.

(a) Turn CAL-SYNC-SEL switch to CAL position. Reduce oscillator output to zero. Ground the terminal of the pilot lamp socket that has only one soldered lead.

(b) A partially clipped sine wave should appear on the analyzer scope. Return to LINE position. Remove ground from pilot lamp socket.

4. VIDEO FILTER.

(a) Reconnect scope lead to pin 15 - J1301. Increase oscillator frequency to 1500 cps. Adjust output to 1/2 screen scale.

(b) Turn the VIDEO FILTER switch from OUT to LOW to HI. The signal should become smaller each time in the proportion of 5 to 2 to .4.

5. INTENSIFIER and Blanking.

(a) Connect scope lead to pin 8 - J1301.

(b) Disconnect the output of audio oscillator from pin 16 J1301. Turn the INTENSIFIER control fully counterclockwise.

(c) Adjust the MARKER LEVEL control to give a full scale pip on the CRT screen of the analyzer with the GAIN control adjusted to give a very small amount of noise on the baseline. AMPLITUDE SCALE set to LIN.

(d) The blanking pulse appears as a negative pip approximately 40 Vp-p under the baseline of the test scope.

(e) Turn the INTENSIFIER control fully clockwise and the marker pip will appear as a positive pulse approximately 30 V p-p on top of the baseline of the test scope.

6. ASTIGMATISM.

(a) Disconnect the scope lead from J1301. Turn the INTENSIFIER control fully counterclockwise.

(b) Connect a voltmeter to pin 12 - J1301.

(c) Rotate the ASTIG control slowly counterclockwise. The voltage should rise from approximately +45 V to +195 V.

7. Frequency Response.

(a) Remove the "cheater" cable from the Horizontal and Vertical Amplifier sub-chassis and reinstall the unit in the analyzer.

(b) Disconnect P1103 from the 6.5 mc i-f amplifier. Connect the output of the audio oscillator to P1103.

(c) Adjust the oscillator to give a 600 cycle signal to cover the full scale of the CRT screen. If necessary adjust the V POS control to center the signal with the least amount of distortion. Measure the rms voltage of the oscillator output. It should be approximately 2 volts.

(d) Tune the oscillator for a 24 kc signal. Adjust the voltage output to be exactly the same as found to be in par. (c) above.

(e) The signal on the CRT screen should now cover from 0 to the .7 level of the CRT scale.

(f) Reconnect P1103 to J1103.

f. 6.5 Mc, I-f AMPLIFIER ALIGNMENT. (Fig. V-4).

This amplifier strip requires alignment of the i-f transformers located on both the 75 mc i-f amplifier and the 6.5 mc i-f amplifier strips (Z1001, Z1101, Z1102, Z1103, and Z1104). In addition, the two crystal filter stages (C1119, L1101 and C1135, L1103) must be aligned. This may be accomplished with the amplifier chassis mounted in place on the analyzer frame.

Begin by obtaining two signal pips of equal heights (full scale) on the CRT screen. One of the signals is obtained from the marker oscillator and the other from a signal generator through the RF INPUT jack. The following instructions are given with the assumption that the two signals are present on the CRT screen.

NOTE

If no signals can be obtained in this manner because of troubles preceeding

the 6.5 mc i-f amplifier, proceed to par. 1. below. A complete alignment for bandwidth and spurious signal rejection will have to be made at a later time when the signal path can be obtained with the two signals. (See par.f.3.)

1. If the stages of the 6.5 mc i-f amplifier are so detuned that no signal or noise appears on the screen, make sure that all the tubes are in good condition. Turn the IF GAIN pot fully clockwise and feed a very strong 6.5 mc signal into J1101. The baseline of the CRT screen should rise to some degree. Proceed to step (a) below and tune for more gain. Then reconnect J1101 to a swept 6.5 mc signal from an FM generator. If the display shows a presentation similar to that in Fig. V-8a, read through all the instructions in the following paragraphs pertaining to 6.5 mc i-f alignment. Use enough of this information for a true signal given in par. f.3. a & b to obtain the pip shape required for continuing the alignment. This requires a working 75 mc i-f amplifier and a 160 mc narrow band i-f amplifier.

(a) Observe the height of the vertical deflection. Set the slug screws of L1101 and L1103 to be 1/8" out of their locknuts. Then tune the transformers (one core at a time) for maximum signal amplitude. When adjusting the top cores, turn the core counterclockwise until mechanical resistance is felt at the end of the core rotation, then turn clockwise for maximum signal amplitude. When adjusting the bottom cores, turn the core clockwise until mechanical resistance is felt at the end of the core rotation, then turn counterclockwise for maximum signal amplitude. Perform this alignment for each transformer starting at the input stage (Z1101) and proceeding back to the final stages (Z1104). Reduce input signal strength and turn GAIN con-

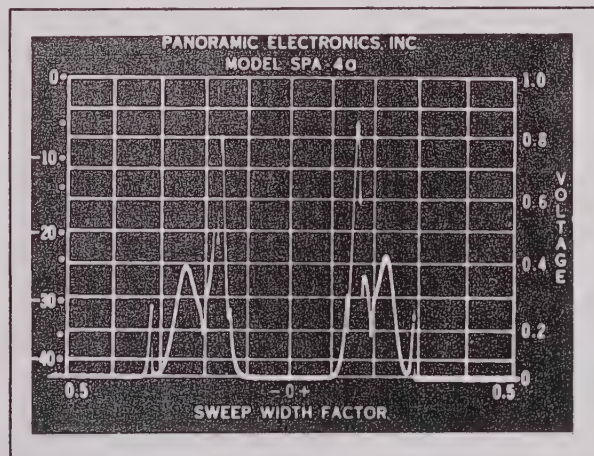


Figure V-8a. CRT Screen Presentations (6.5 MC I-F Amplifier Detuned)

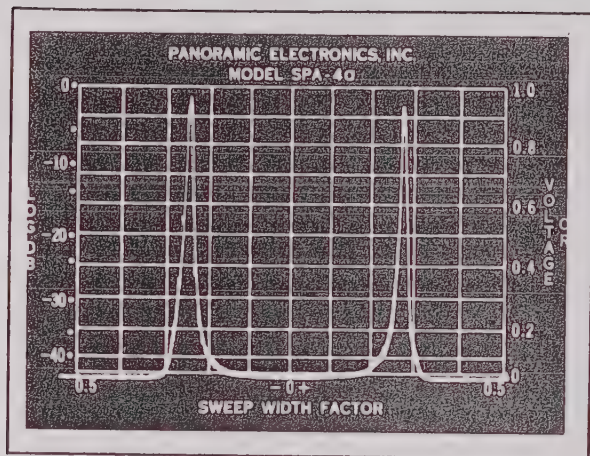


Figure V-8b. CRT Screen Presentations
(6.5 MC I-F Amplifier Detuned)

trol CCW as gain is increased. It will also be necessary to reduce sweep width so that a good presentation can be viewed. (Fig. V-8b)

CAUTION

Do not force the cores beyond the first sign of resistance in either direction. To do so may crack the cores or cause them to "freeze" necessitating replacement of the complete transformer.

2. Crystal Filter Stages. With the desired input of the two signals (marker and generator pips) passing through the various stages, tune for maximum amplitude in the manner described above (par. f.1).

(a) When maximum amplitude is reached, remove the r-f generator input, and adjust the GAIN control on the front panel until a very small amount of noise (approximately 1/32") appears on the baseline. Then adjust the MARKER LEVEL control until the marker signal is equal to full screen scale.

A neutralizing air-trimmer capacitor is mounted near each crystal on the 6.5 mc i-f strip. THESE CAPACITORS MUST BE TUNED WITH AN INSULATED SCREWDRIVER, PREFERABLY A SHARPENED PHENOLIC ROD.

(b) Remove crystal Y1101 from its socket. Reduce the SWEEP RATE to approximately 6 cps. Turn the IF BANDWIDTH control fully clockwise. Turn the VIDEO FILTER to LOW. (This should not reduce the height of the pip if the sweep rate is slow enough).

(c) Remove crystal Y1102 part way from its socket until crystal to socket capacitance

changes the Q of the filtering circuit. A 6.5 mc marker "birdie" should appear on the pip. It may also be necessary to further reduce SWEEP WIDTH so that the "birdie" may be seen.

Tune all the transformers so that the "birdie" appears centered in the expanded pip (Fig. V-9a). Push the crystal Y1102 fully into its socket and reconnect the signal generator input.

(d) Turn C1135 slowly until the signals have approximately the shape shown in Fig. V-9b (or its mirror image). As C1135 is slowly rotated in the same direction, the pip shape will change and the rejection slot will disappear and return on the opposite side. Repeat this slowly once or twice and note whether there is any asymmetry in the height of the humps on the outer sides of the rejection slots. Slowly turn the trimmer until the smaller hump appears to be peaked.

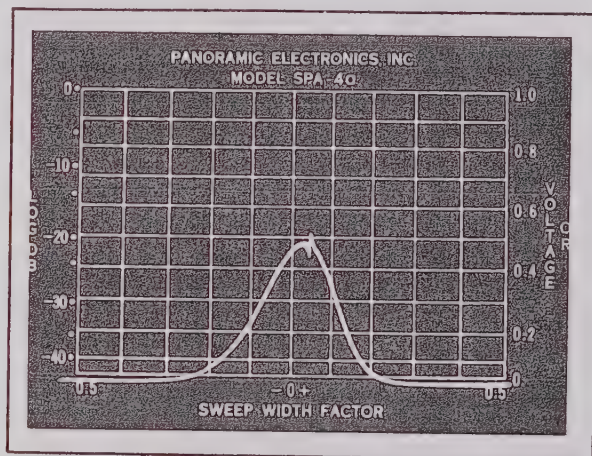


Figure V-9a. CRT Screen Presentations
(6.5 MC I-F Amplifier Alignment)

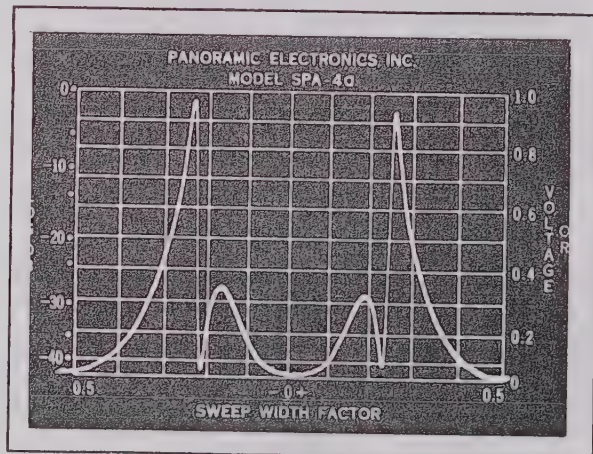


Figure V-9b. CRT Screen Presentations
(6.5 MC I-F Amplifier Alignment)

NOTE

If there is less than 3:1 difference in the humps on the outer sides of the rejection slots proceed to step (f) below.

(e) Carefully adjust the bottom core of Z1102 and the top and bottom cores of Z1103 until the smaller rejection slot deepens. It is important that the progress of this adjustment be checked often by rotating C1135 around to show both rejection slots of each signal pip. It may be found that it is difficult to obtain symmetry of both rejection slots at better than 3:1. In that event proceed to step (f).

(f) Slowly reverse the rotation of C1135 until a point where the best pip symmetry is obtained (See Fig. V-9c) and the rejection slot is not present. Carefully adjust the slug screw of L1103 until the pips reach minimum deflection and best symmetry.

(g) Replace crystal Y1101 and remove crystal Y1102 from its socket.

(h) Slowly rotate C1119 and note the height of the humps on the outer sides of the rejection slots. Proceed with the adjustments of the top core of Z1102 and both cores of Z1101 and slug of L1101 in the same manner as described in steps c, d, e, and f above.

(i) Replace crystal Y1101 and connect an audio oscillator to the MARKER MOD connector on the front panel.

(j) Adjust the audio oscillator for an 80 KC signal and adjust the output until the 80 KC sidebands move up one slope of the marker pip and the first sideband is of equal height with the center peak of the pip. (Fig. V-10a). If the 6.5 mc i-f transformers are correctly tuned, the -3 db point (peak to valley distance between the marker pip and its first sideband) should be approximately .7 of the full LIN scale. Any indication of a greater distance than this calls for further adjustment of the various coils. See par. 3 below.

3.6.5 Mc I-f Bandwidth alignment.
Check to see that the marker pip with its 80 KC modulation and the signal pip are of equal height at full screen scale. Note the signal generator power output setting, then add another +20 dbm of power. The resultant display should resemble Fig. V-10a with the top 20 dbm of the r-f signal over the top of the screen. Note the spurious responses on the lower left base of the r-f signal. These are caused by secondary response characteristics of the two 6.5 mc crystals and must be tuned out for at least 40 dbm down from the signal peak. These spurious responses may be tuned out to better than 50 dbm down, while still maintaining the required 80 KC bandwidth, depending upon the skill of the servicing technician. (See Fig. V-10b)

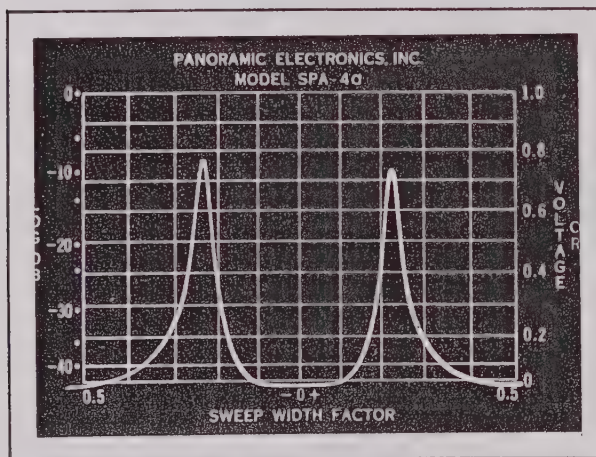
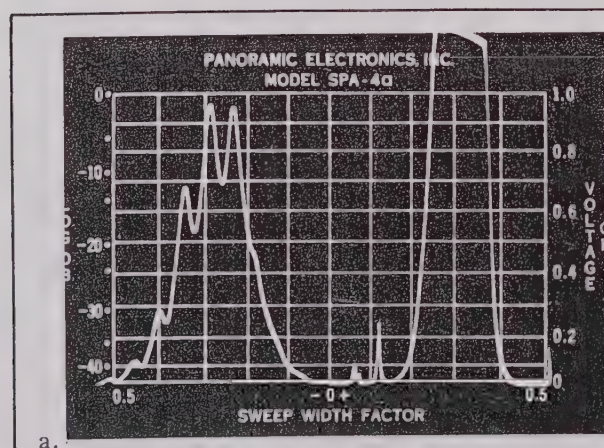
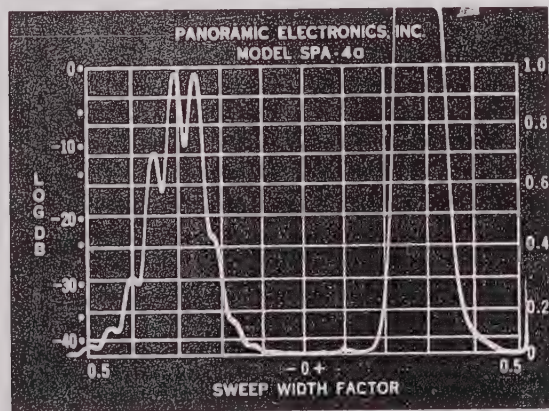


Figure V-9c. CRT Screen Presentations (6.5 MC I-F Amplifier Alignment)



a.



b.

Figure V-10. CRT Screen Presentations (6.5 MC I-F Amplifier Alignment).

(a) When the transformers are acutely detuned, a presentation such as shown in Fig. V-8a will appear. In such a case the true signal is the one on the RIGHT of the r-f signal pips while the true marker signal is the one on the LEFT of the marker pips. The r-f signal and marker pip can easily be identified by changing the input frequency of either one of them. The signal that moves across the screen is the one being tuned.

(b) Refer back to par. f. 1.(a) for instructions concerning the technique of tuning the r-f transformers Z1001, 1101, 1102, 1103 and 1104. While performing the alignment of these transformers, concentrate on improving the true r-f and marker signals. The spurious responses will gradually disappear.

It will be observed that as the bandwidth of the i-f response decreases, the spurious indications will also decrease, but the peak-to-valley distances of the marker pip and its 80 KC modulation will increase. It will be necessary for the servicing technician to back-track and make fine adjustments where required to bring in the desired waveshapes shown in Fig. V10-b.

(c) The filter tuning coils L1101 and L1103 are used to broaden the bandwidth response of the filter circuit. Noting the peak-to-valley display of the marker pip and its 80 KC modulation, carefully tune the slugs to obtain a minimum horizontal distance between peak and valley at the same time maintaining symmetry of waveform.

4. Minimum Bandwidth Check. All the above adjustments were made with the IF BANDWIDTH control in a fully clockwise position. When the 80 KC response is successfully achieved, a check for the minimum bandwidth requirement of 1000 cps should be made.

Slowly turn the IF BANDWIDTH control counterclockwise. A perfectly tuned 6.5 mc i-f amplifier will produce the effect of the slopes of all pips falling away symmetrically on both sides of the pips. However, such a result is not essential for good operation of the analyzer.

(a) Tune the audio oscillator for a 1000 cycle signal. As the IF BANDWIDTH and the SWEEP WIDTH controls are turned counterclockwise, an optimum point will be reached where the separation between the marker signal and its modulation pips will be more than 3 db down. This will indicate that the minimum bandwidth of the 6.5 mc i-f amplifier is 1000 cycles or less.

g. ADJUSTMENT OF IF GAIN, LOG -20 DB, LOG -0 DB AND PWR SCALE CONTROLS.

1. IF GAIN. Turn SWEEP WIDTH RANGE switch to 0 - 5 MC position. Turn the front panel GAIN control fully counterclockwise and the IF BANDWIDTH control fully clockwise. Set the VIDEO FILTER switch to the OUT position. Then turn the IF GAIN control on the 6.5 mc i-f amplifier clockwise until noise just appears on the baseline.

2. LOG -20 DB & LOG -0 DB. These two adjustments are made simultaneously.

(a) Obtain the two signals on the baseline from the R-F INPUT signal and the unmodulated marker pip. Adjust the amplitude of these signals to full scale deflection. Use care in adjusting for equal amplitude signals and that they measure exactly from 0 to 1.0 in amplitude.

(b) Turn the AMPLITUDE SCALE switch to the LOG position. Both signals should drop to -20 on the LOG scale. Add 20 DB of power from the r-f signal source. The signal should rise to 0 db at the top of the LOG scale.

(c) If the two signals do not reach their respective heights, it will be necessary to adjust the LOG -0 DB and LOG -20 DB screwdriver adjust controls until the optimum points are reached.

3. PWR SCALE. Use only the external signal from the r-f generator.

(a) Turn the AMPLITUDE SCALE switch to the PWR position. Adjust the signal to exactly full scale.

(b) Reduce the signal input by exactly 3 DB. The signal pip should drop to .5 on the VOLTAGE or PWR scale.

(c) If the .5 level is not reached, adjust the PWR SCALE pot until this point is attained.

h. 75 Mc I-f AMPLIFIER ALIGNMENT (See Fig. V-4)

1. The 75 mc i-f amplifier requires alignment of L1001, L1003, L1005, L1007, L1009, and L1013. Z1001 is considered to be part of the 6.5 mc i-f amplifier and is only adjusted when it is being tested after repair or replacement.

NOTE

Model SPA-4 and SPA-4a Spectrum Analyzers with serial numbers #101 to 190, require a slightly different procedure from those numbered #190 and above. This is defined below in Par. h 3 & 4.

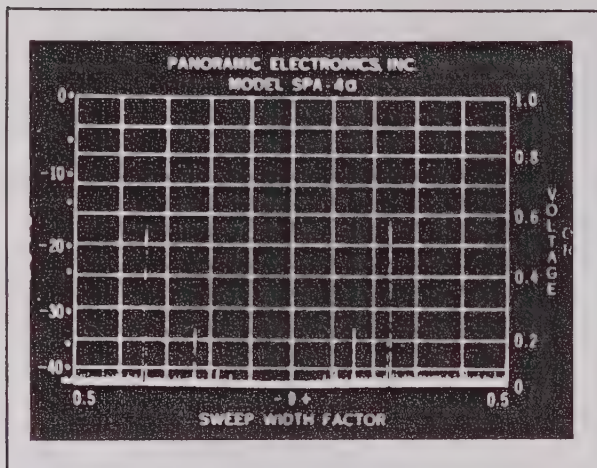


Figure V-11. 75 MC I-F Amplifier Display with 6.5 MC Oscillator Detuned

2. 68.5 Mc Oscillator. (V1007). This is a crystal controlled oscillator stage which is locked on frequency by crystal Y1001 which has a natural resonance at 68.5 mc. The tuning coil, L1013, has a very broad adjustment range because the crystal tends to hold the oscillator stable for comparatively large changes in circuit conditions. The oscillator characteristics of this circuit are such that, if the slug of L1013 is tuned through from maximum to minimum travel, there will be no oscillations until the slug reaches approximately mid-way. The circuit will then suddenly break into oscillation and remain that way for about 3 or 4 turns of the slug and then fall out of oscillation.

(a) Fig. V-11 shows the display which appears on the screen when the oscillator stage is not working. Any signal will appear as a series of double pips which will move across the screen as the signal is tuned. These can be observed when the GAIN control on the front panel is turned fully clockwise. (At normal GAIN setting, neither signal or noise will appear).

(b) If adjustment of L1013 does not make the circuit oscillate, replace V1007 (12AT7). Check the a-c line voltage for proper level (105-125 VAC).

(c) Standard troubleshooting methods such as feeding a modulated 75 mc signal through a .001 capacitor into pin 5 of socket X1004 will aid in determining whether this stage is operating or not.

3. Alignment - Serial Numbers 101 - 190.

(a) Disconnect the input cable from J1001. Turn the GAIN control on the front panel fully clockwise.

(b) Connect a modulated 75 mc signal from a generator to J1001. Connect the vertical input of a test oscilloscope to the SYNCHROSCOPE OUTPUT jack on the front panel. Adjust the generator output for 30% modulation and to give a usable response on the test scope.

(c) Align L1001 and L1003 for maximum gain. Reduce generator output if necessary.

(d) Tune the generator to 77.2 mc and align L1005 for maximum gain.

(e) Tune the generator to 72.8 mc and align L1007 for maximum gain.

(f) Repeat the above steps (c), (d) and (e) for optimum results.

(g) Set the VIDEO FILTER knob to LOW position and turn the GAIN control counterclockwise for a half scale presentation on the analyzer CRT.

(h) Tune the generator to 75 mc and align L1009 for maximum gain on the analyzer CRT.

(i) Remove all test equipment and re-connect cable to J1001.

4. Alignment of Serial Numbers 190 and above.

(a) Repeat instructions in Par. 3(a) and (b) above.

(b) Align L1001 and L1007 for maximum gain. Reduce generator output as necessary.

(c) Set the generator to 72.8 mc and align L1003 for maximum gain.

(d) Set the generator to 77.2 mc and align L1005 for maximum gain.

(e) Repeat steps (b), (c) and (d) above for optimum results.

(f) Set the VIDEO FILTER knob to LOW position and turn the GAIN control counterclockwise for a half scale presentation on the analyzer CRT.

(g) Tune the generator to 75 mc and align L1009 and L1011 for maximum gain on the analyzer CRT.

(h) Remove all test equipment and re-connect cable to J1001.

i. 160 Mc NARROW BAND (0-5 mc) I-F AMPLIFIER ALIGNMENT.

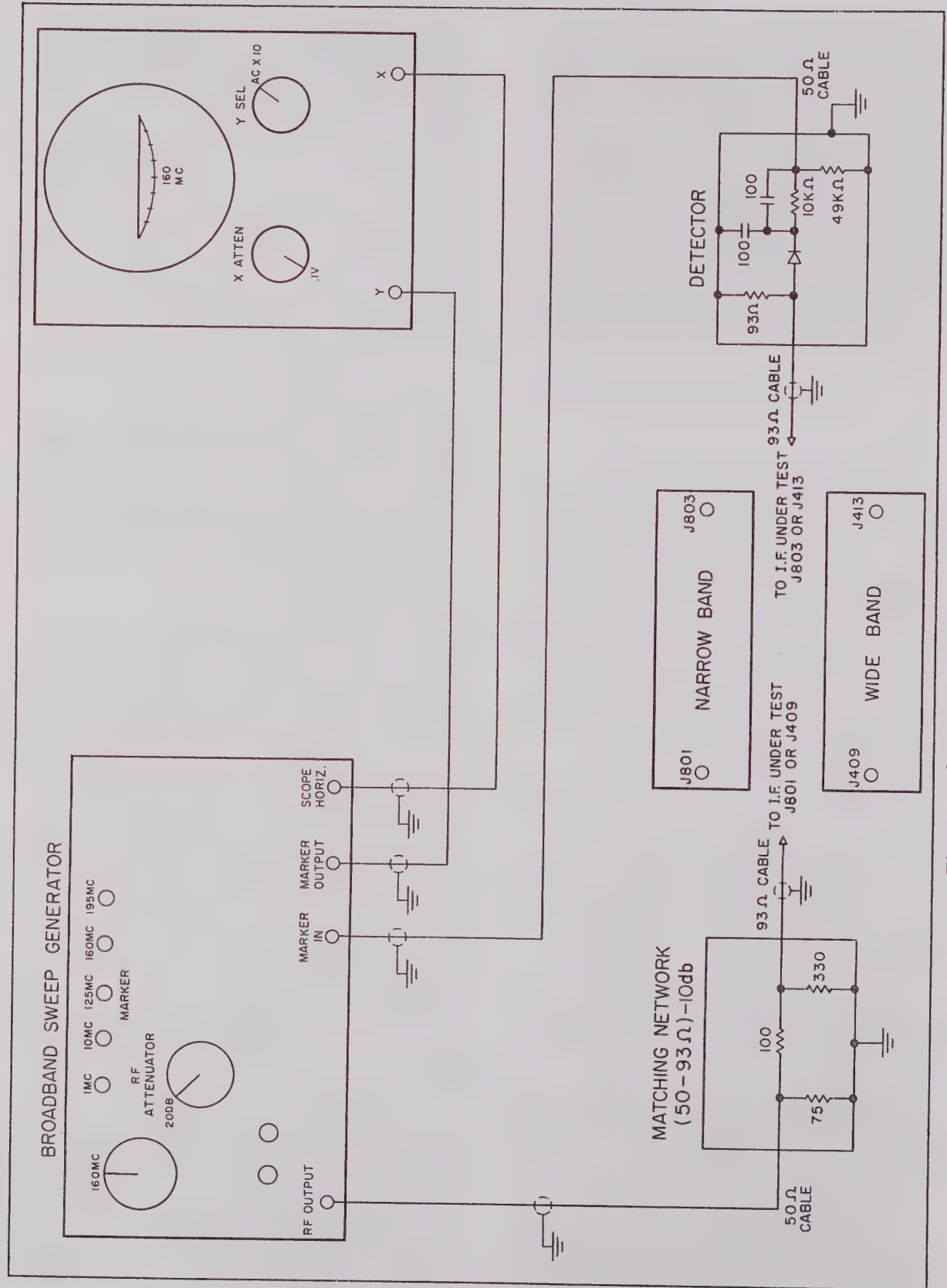


Figure V-12. 160 MC I-F Test Set-up (SPA-4a)

1. Test and alignment Equipment. Alignment of the 160 mc narrow band amplifier requires specially made pads and detectors, various fittings, adaptors and cables. The minimum required equipment is listed below:

Broad Band Sweep Generator - Telonic Model HD-1 Mod

High Gain Oscilloscope - Dumont 401 or equivalent
R-f Signal Generator - H-P Model 608D or equivalent

Crystal Calibrator - Measurements Corp. Model 111

Variable Line Transformer - 1KVA

1 Pad, 6 db - BNC to BNC

2 Pads, 10 db - BNC to BNC

1 Pad, 20 db - BNC to BNC

1 Matching Network, 10 db - 93 ohms to 50 ohms
conhex to BNC

1 Crystal detector, 93 ohms, conhex to conhex

Cables and adapters from BNC to conhex to Type "N"

2. Preliminary Alignment (Fig. V-4 and Fig. V-12)

(a) With the narrow-band amplifier installed in the analyzer, connect J805, J809, and J811. MAKE SURE A-C LINE VOLTAGE IS 115 V.

(b) Connect the r-f output of the broad-band sweep generator through a 20 db pad and a matching network (93 ohm to 50 ohm) in series to J801. Tune the sweep generator to center at 160 mc with .4 v p-p output.

(c) Connect J803 to a 93 ohm detector with the negative end to the amplifier.

(d) Connect the positive end of the 93 ohm detector to the MARKER IN jack on the sweep generator. Set markers to 160 MC and 1 MC.

(e) Connect the MARKER OUT jack of the sweep generator to the vertical input of the oscilloscope set to 100 mv full scale.

(f) Connect the horizontal input of the oscilloscope to the HORIZ OUTPUT of the sweep generator. Adjust the scope sweep width to show 160 mc ± 3 mc. (The marker pips will feed through regardless of condition of narrow band amplifier).

(g) Align L801, L805, L807 and L815 to get maximum response with a good symmetrical output between 157 mc and 163 mc as shown in Figure V-13a.

NOTE

Figure V-13a shows the response of Model SPA-4a serial nos. 201 and up.

The response of serial nos. 151-200 will show a noticeable tilt of 2 db to -4 db down.

(h) Gain of the amplifier stages should be over 25.

(i) Connect the detector to J805 and add another 10 db pad in series with existing 20 db pad. The response should appear as in Figure V-13b.

NOTE

Figure V-13b shows response of Model SPA-4a serial nos. 201 and up. The response of serial no. 151 - 200 will show the 160 mc marker 4 db or less up the slope of the response.

(j) Reconnect J801 and J803 to proper cables. The display will now be shifted to the

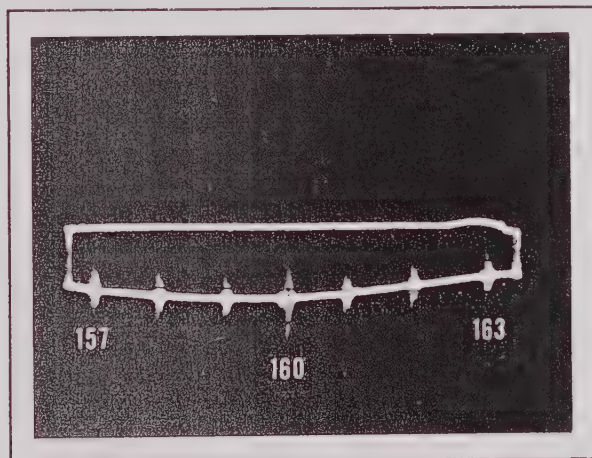


Figure V-13a. 160 MC Narrow-Band I-F Response (J803).

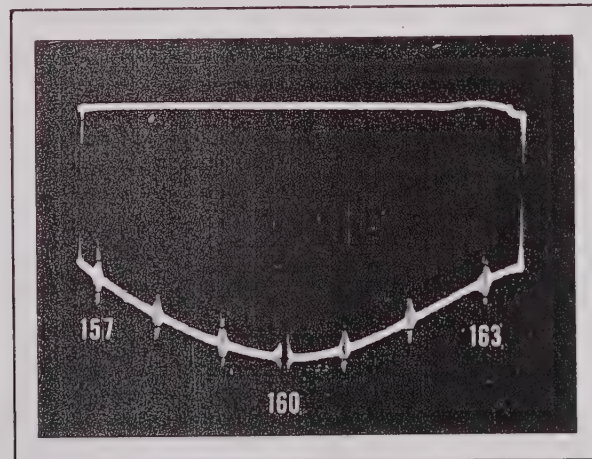


Figure V-13b. 160 MC Narrow-Band I-F Response (J805).

analyzer crt. Center the marker pip by setting the marker dial to 0 and the CENTER FREQ control to center position. Then adjust the 5 MC screwdriver SWEEP WIDTH control with the SWEEP WIDTH CONT control fully counterclockwise so that the marker pip expands horizontally and rises to the top of the CRT screen scale. This will serve to zero the narrow band response. Turn the SWEEP WIDTH CONT control fully clockwise.

(k) Adjust limits of sweep width to ± 2.5 mc using the 0 - 5 MC screwdriver SWEEP WIDTH control. This primarily affects the (-) side of the screen. The (+) side of the screen is adjusted with use of L823.

(l) Touch up L801, L805, L807, and L833 so that the response curve displayed on the screen is flat within $\pm .5$ db across the 5 mc sweep width. (See Figure V-13c).

NOTE

Serial nos. 201 and up will have a flat response as above. Serial nos. 151 - 200 will have a tilted response running upward from left to right.

3. Preliminary Alignment of Narrow Band Filters. This paragraph concerns alignment of the 170 mc trap and the band pass filter for the narrow band i-f amplifier. These networks are designed to provide maximum attenuation of all signals and their harmonics which fall close to the band-pass range of the narrow band i-f amplifier (157 - 163 mc). Because of their relatively high amplitudes, they might possibly produce spurious responses in the following 75 mc and 6.5 mc i-f amplifiers.

(a) Connect RF output of the broadband sweep generator through a 10 db pad and 93 ohm

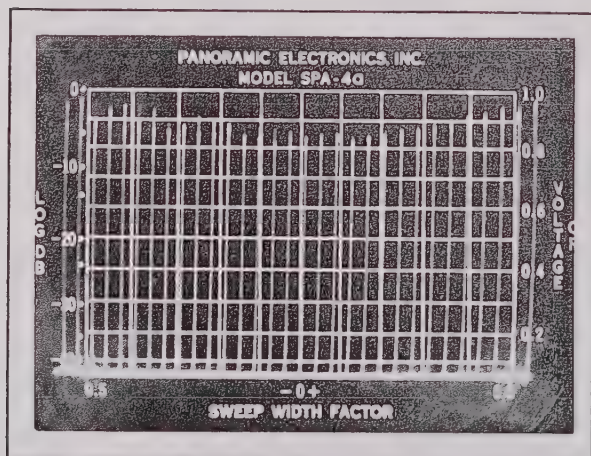


Figure V-13c. 160 MC Narrow-Band Display.

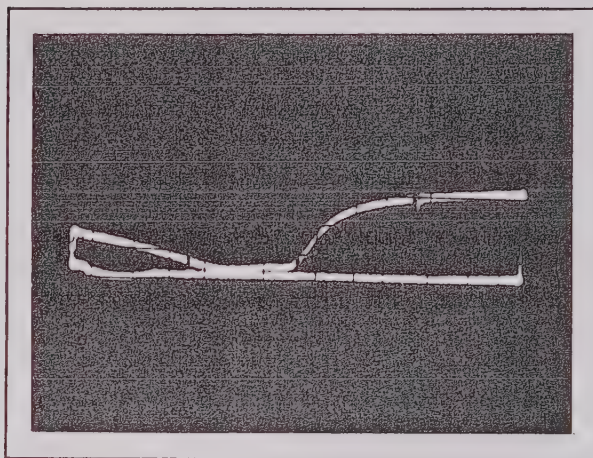


Figure V-14a. FL 101 Response.

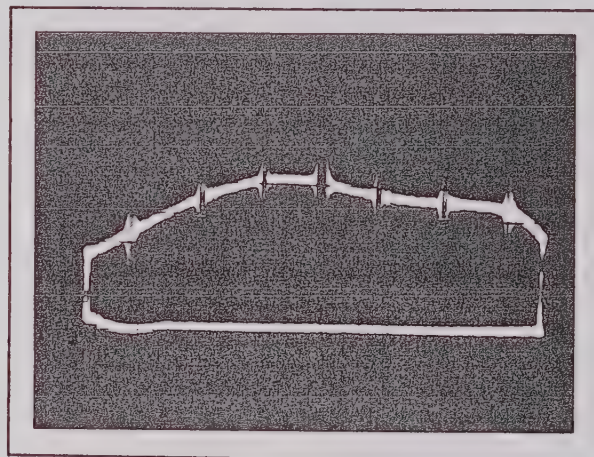


Figure V-14b. FL 101 Response.

matching network to J417 of F1401. Connect J419 through a 93 ohm detector to the MARKER IN jack of the broadband sweep generator similarly to hookup shown in Figure V-12.

(b) Using the 160 mc and 10 mc marker pips, adjust L437 and L438 so that the pattern on the oscilloscope screen has a dip of at least 10 db at 170 mc. (See Figure V-14a). The rejection range should be fairly flat between 170 mc and 180 mc.

(c) Remove the detector from J417 and reconnect it to J423. Move the matching pad to J421 (without the 10 db pad).

(d) Align C464, L440 and L441 and finally L439 in that order to obtain the response similar to that shown in Figure V-14b.

(e) With the sweep generator output set to .75 v p-p, the response shown in Figure V-14c

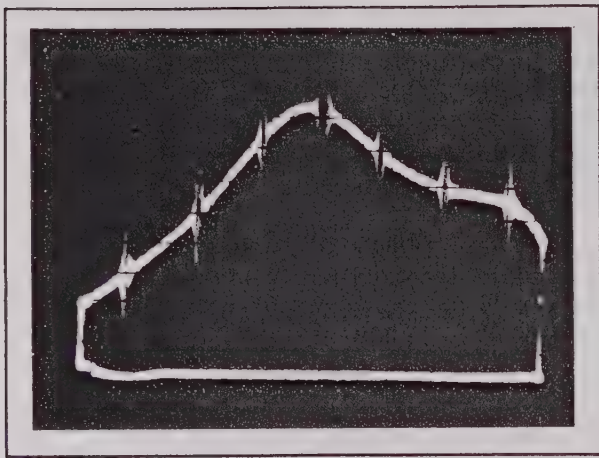


Figure V-14c. 160 MC Narrow-Band and Filter Over-all Response.

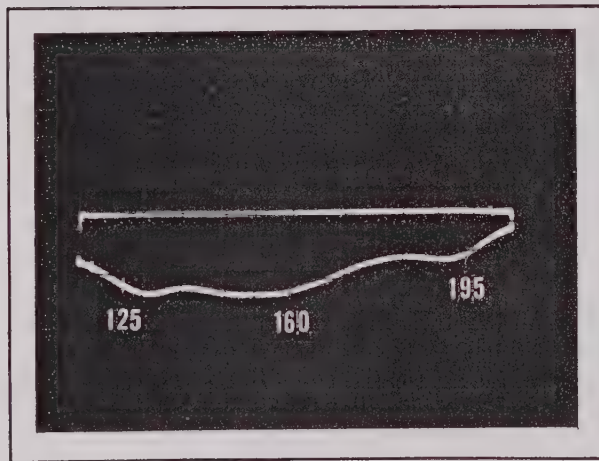


Figure V-15. 160 MC Wide-Band Response

should not be less than .5 v p-p. Greater losses are caused by misalignment of the components in FL403.

NOTE

The response of the filter FL403 will be fairly flat to ± 1 db in serial nos. 251 and up. Serial nos. 151 to 250 will show a tilt opposite to that of the narrow band i-f amplifier.

(f) Remove the detector from J423 and connect it to J803. Reconnect the jumper cable W39-02 between J423 and J801. Connect the matching pad with a series 10 db pad to J417.

(g) The resulting response, as viewed on the oscilloscope screen, will closely resemble Figure V-14c and should be approximately the same for all units with serial nos. #151 and up.

(h) Repeat steps 2 (j), (k) and (1) above with the exception that the broadband sweep generator is connected to cable W39-08 at the output of the pre-amplifier chassis and J805 is now connected to its proper terminal jack. The resulting hook-up should now be with the sweep generator acting as a signal source through the K401 co-ax switch, the filters FL401 and FL403, the narrow band amplifier, 75 mc and 6.5 mc i-f amplifiers and the crt circuits.

The purpose of this set-up is to re-check and realign where necessary, the narrow-band i-f amplifier and filters, in order to obtain as good an overall response as possible. It will be found that touching up L440, L441 & L439 will produce the best result.

NOTE

Serial nos. 251 and up should be $\pm .5$ db or better. Serial nos. 151 - 250 should be ± 7.5 db or better.

j. 160 Mc - WIDE BAND (0-70 Mc) IF AMPLIFIER ALIGNMENT.

The test set-up to be used in the alignment of the wide band i-f amplifier is the same as used in the alignment of the narrow band i-f amplifier. The same pads, detectors and fittings may be used. The SWEEP WIDTH RANGE switch is set to the 0-70 MC position for this alignment. See paragraph n for servicing hints on the amplifiers before proceeding with the alignment procedures. Make sure the line voltage is set at 115 Vac.

1. Preliminary Alignment for Wide-Band I-f. Amplifiers in units with Serial Nos. 201-300.

(a) Connect the power cables to J403 and J605.

(b) Connect J601 to the lower right terminal of K401.

(c) Connect RF OUTPUT of the broadband sweep generator, with the 50 to 93 ohm matching pad in series with a 10 db pad, to J409.

(d) Connect J413 through the 93 ohm detector to the MARKER IN jack of sweep generator.

(e) Adjust C497, C507, C509, C519 and C523 so that the response curve of the amplifier section is similar to Fig. V-15.

(f) Reconnect J413 to the marker cable "T" connector and W47-01 and W39-07. The swept display will now appear on the analyzer crt.

(g) Adjust the MARKER LEVEL control until a full scale marker pip appears on the screen. Zero the marker dials.

(h) Center the 160 mc marker pip by adjusting the 70 mc screwdriver CENTER FREQ control and tuning the SWEEP WIDTH CONT knob fully counterclockwise. When the baseline rises to the top of the screen scale, it indicates that the sweep is centered. Now turn the SWEEP WIDTH CONT knob fully clockwise.

NOTE

Serial Nos. 251 and up have an 80 MC sweep width. All information following should be read as ± 40 MC for these serial numbers.

(i) Turn the 70 mc RANGE marker dial to determine the end limits (± 35 mc) of the sweep. If the ± 35 mc points do not coincide with the ends of the screen scale, it will be necessary to align the sweep linearity by adjusting the CF LIN screwdriver adjust control for the (+) end of the screen and the 0-70 MC SWEEP WIDTH RANGE screwdriver adjust control for the (-) end of the screen. If the linearity cannot be adjusted within $\pm 1/2$ division on the screen scale, check the sawtooth voltage at J603 (W41-04). It should be more than 50 V p-p with the SWEEP WIDTH CONT control and SWEEP WIDTH RANGE (0-70 mc) switch fully clockwise.

(j) Turn the SYNC AMP control fully counterclockwise and the SWEEP RATE control slightly off the 60 cycle point until the most pips appear moving across the screen. The display will be similar to that shown in Fig. V-13c.

(k) Touch up the adjustments of C497, C507, C509, C519 and C523 until the response is flat within $\pm .5$ db.

(l) Remove the sweep generator cable from J409 and reconnect all cables normally.

2. Preliminary Alignment for Wide Band I-f Amplifiers in units with Serial Nos. 151-250. (Fig. V-3a).

(a) With the amplifier chassis installed in the analyzer, connect J403, J413, J601, J603 and J605 to their proper cables.

(b) Repeat steps (g), (h), (i) and (j) above.

(c) Carefully observe the response curve, noting the location of all irregularities. Note the effect of each adjustment so they may be touched up to produce the desired result during the alignment.

(d) Proceed to adjust the coils and trimmers as listed in the following order: L501, L497, L485, L487, L489, L467, L469, L459, L451, L435, L447, L449, L457, L465, L463, L491, L495, L499.

(e) After the best flatness response is obtained, adjust L605 for maximum gain.

(f) Repeat step (d) above until a response is obtained which is flat within ± 1 db. This alignment requires patience and care. The skill of the technician is of utmost importance in order to obtain optimum results.

(g) Because this method of alignment does not provide a continuous presentation of the amplifier response, but rather a random view of tiny sections of the response characteristics, it is possible to overlook small areas of irregularity. A check should be made for sharp dips or peaks in the following manner:

Attach the 93 ohm detector to J413 and connect it to the vertical amplifier of the test oscilloscope. The display should look very similar to that in Fig. V-15 with the 195 mc end being tilted 2 or 3 db toward the baseline. If objectionable sharp dips or peaks (greater than 1 db) exist, it will be necessary to touch up the appropriate coils.

(h) If a sharp dip exists between 155 mc and 165 mc on the response curve, it may be caused by a reverse turn on the coupling to J605. Reverse the direction of this turn taking care not to change the lead dress of the coupling.

(i) Restore all connections and cables to their normal locations.

k. SENSITIVITY AND GAIN MEASUREMENTS OF THE 160 Mc IF AMPLIFIERS.

1. Sensitivity Measurements (Wide Bands)

(a) Insert a 160 mc cw signal from a signal generator through a 93 ohm pad to P407 of W39-08. Set the AMPLITUDE SCALE switch to LIN position.

(b) Set the SWEEP WIDTH RANGE switch to the 0 - 70 MC position. Working back and forth, slowly adjust the SWEEP WIDTH CONT and the IF BANDWIDTH controls counterclockwise and adjust the GAIN control and generator output until optimum resolution of the signal is attained at twice noise level.

(c) Record the reading of the signal generator output including the 93 ohm (-10 db) pad. Serial nos. 151-250 should be -118 dbm

or better. Serial nos. 251 and up should be between -122 and -128 dbm.

2. Gain Measurements (Wide Bands)

(a) Connect the signal generator through the 93 ohm pad (-10 db) to P601 (W39-05). Tune the signal generator to 75 mc with -70 dbm output power. Turn the SWEEP WIDTH CONT control clockwise. Adjust the GAIN control until full scale deflection of the baseline is attained.

(b) Leave the GAIN control at this setting and reconnect P601 to J601.

(c) Connect the 93 ohm pad from the signal generator to P407 (W39-08). Tune the signal generator to 160 mc and adjust its output until the top of the signal pip reaches full scale deflection.

(d) Subtract the power setting (-70 dbm in step (a) above) from the new reading just obtained. The difference will be the overall gain of the wide-band amplifier.

Serial Nos. 151-250 should equal between 7 - 9 db.
Serial Nos. 251 and up should equal between 5 - 7 db.

(e) To determine the gain of the amplifier stages only, perform a similar check by injecting a 160 mc signal into J413 and measuring a full scale pip on the analyzer screen. Compare this to the reading obtained previously in Paragraph (c) above.

Serial Nos. 151 - 250 should be approximately 30 dbm.

Serial Nos. 251 and up should be approximately 25 dbm.

(f) Reconnect cable W47-01 to J413.

3. Sensitivity Measurements (Narrow-Band).

The procedure for this measurement is made very similar to the procedure given in Paragraph 1 above.

(a) Repeat Paragraph 1 (b) with the SWEEP WIDTH RANGE switch set to the 0 - 5 mc position.

(b) Record the reading of the signal generator output including the -93 ohm (-10 db) pad. All serial nos. from 151 and up should show a sensitivity reading of -115 dbm or better.

(c) To measure the sensitivity of the narrow band i-f amplifier stages only, remove the cable (W39-03) from P417, connect it to J801 and repeat steps (a) and (b) above. The difference between these two readings should be approx-

imately 2 dbm better than with the narrow band filter stages, (or a 2 dbm loss in the filters).

(d) Replace all cables to normal connections.

4. Gain Measurements (Narrow-Band)

(a) Connect the signal generator through a 93 ohm pad to P805 (W39-03). Tune the signal generator to 75 mc with -70 dbm output power. Turn the SWEEP WIDTH RANGE switch to 0 - 5 mc position. Adjust the GAIN control until full scale deflection of the baseline is attained.

(b) Leave the GAIN control at this setting and reconnect P805 to J805. Turn the SWEEP WIDTH CONT control clockwise.

(c) Connect the 93 ohm pad from the signal generator to P407 (W39-08). Tune the signal generator to 160 mc and adjust its output until the top of the signal pip reaches full scale deflection.

(d) Subtract the power setting (-70 dbm in step (a) above) from the new reading just obtained. The difference will be the over-all gain of the narrow-band amplifier and is approximately the same for all serial nos. 151 and up, which is 18 dbm.

(e) When measuring the narrow-band amplifier without filters, the gain should be approximately 28 dbm.

1. 160 Mc PRE-AMPLIFIER ALIGNMENT.

The alignment procedure for the pre-amplifier is identical to the alignment procedure of the wideband i-f amplifier stage of serial nos. 251 and up. However, the SPA-4a Tuning Heads in the field may have been equipped with either 50 ohm or 93 ohm impedance cabling. It is essential while servicing the pre-amplifier that all cabling used in the process be of the same impedance as that connected to the pre-amplifier in the unit. This is to minimize the possibility of the formation of standing waves in the Tuning Head.

1. Connect the RF OUTPUT jack of the broadband sweep generator through 40 db of attenuation to the input jack J405 of the pre-amplifier.

2. Connect the (-) input of the detector to J407 and its output to the vertical amplifier of the test oscilloscope.

3. Adjust C497, C507, C509, C519 and C523 for a complementary response to that of the wide-band i-f amplifier. The pre-amplifier response should tilt in the opposite direction to that of the wideband. It is permissible to have a

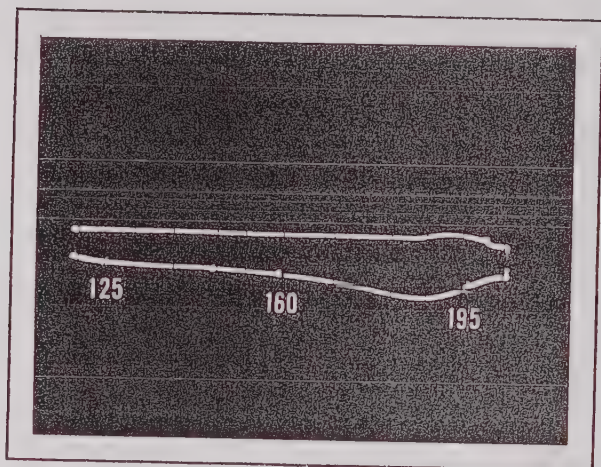


Figure V-16. 160 MC Preamplifier Response

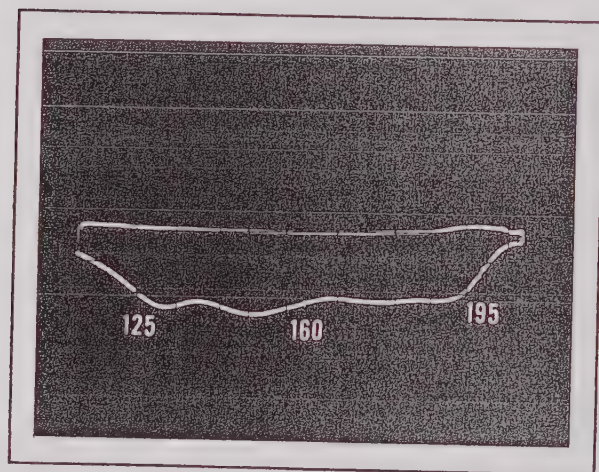


Figure V-17. Over-all Response From R-F Input

level response, but the response should never tilt in the same direction as that of the wide-band. (See Figures V-15 and V-16).

4. Sensitivity is measured in the same manner as the wide-band i-f amplifier stages and should be better than -125 dbm.

5. Gain is also measured in the same manner as the wide-band i-f amplifier stages and should be better than 16 db.

NOTE

Bandwidth of the pre-amplifier should be 80 mc or better at the 3 db points for serial nos. 151 - 250. Bandwidth of the pre-amplifiers should be 90 mc or better at the 3 db points for serial nos. 251 and up.

m. FINAL ALIGNMENT OF IF AMPLIFIERS.

Connect a broadband sweep generator with .75 v p-p output to the DIRECT INPUT jack on the Tuning Head through a 20 db pad. All internal cabling of the analyzer unit is connected normally, except that the vertical amplifier of the test oscilloscope is connected to J413.

1. Wide-Band IF Amplifier.

(a) Set the SWEEP WIDTH RANGE switch to 0-70 MC position, SWEEP WIDTH CONT control fully counterclockwise (zero sweep), and press RANGE 4/3 button.

(b) The response should be fairly level and have no more than 2 db of deviation from flatness, have a magnitude of approximately .03 volts, and a bandwidth of better than 70 mc at the 3 db points (See Fig. V-17).

(c) If the response shape is not satisfactory, adjust the trimmer on the 500/50 ohm matching transformer, Z309, on the input mixer and touch up C407 on the pre-amplifier. It may become necessary to touch up all the trimmers on the pre-amplifier.

(d) Remove the test oscilloscope from J413 and reconnect the proper cables. Remove the sweep generator from the DIRECT INPUT jack and connect in its place a signal generator equivalent to HP Model 612A tuned to approximately 1150 mc with approximately 50 microvolt output.

(e) Turn the SWEEP WIDTH CONT control fully clockwise. Set the AMPLITUDE SCALE switch to LIN. Tune the SPA-4a until the signal pip appears on the Indicator screen and adjust the GAIN control until the pip has full scale deflection with about 1/32" of noise on the baseline.

(f) Tune the signal generator so that the signal travels across the Indicator screen, at the same time holding the signal generator output at a constant level. Note the variations in signal amplitude on the screen. The response level should be better than ± 1 db.

(g) If the signal response is not satisfactory - On serial nos. 151 - 200 touch up the trimmers on the pre-amplifier. On serial nos. 201 and up, touch up trimmers C497, C507, C519, and C523 on the wide-band i-f chassis.

(h) Check the sensitivity at this point by adjusting for optimum resolution. It should be -100 dbm or better at twice noise level. If necessary adjust the XTAL BIAS control for Range 2 for optimum sensitivity.

(i) Turn the GAIN control until there is about $1/16''$ of noise on the baseline. Carefully check for spurious signals at about 168 mc on the baseline. If any exist, it will be necessary to tune L1001 on the 75 mc i-f and L605 on the wide band i-f until the signal minimizes or disappears. There will also be an indication of a slight gain.

2. Narrow Band I-f Amplifier.

(a) Turn the SWEEP WIDTH RANGE switch to 0-5 MC position and the SWEEP WIDTH CONT control fully clockwise.

(b) Adjust the marker pip so that it is exactly in the center of the narrow-band i-f band pass. Set the two MARKER dials on "0", or feed in a calibrated 160 mc signal.

(c) Turn the SWEEP WIDTH CONT control slowly counterclockwise, at the same time adjusting the CENTER FREQ and GAIN controls to make the baseline rise to full scale. Then turn the SWEEP WIDTH CONT control fully clockwise. The marker pip will now be in the center of the bandpass.

(d) Turn the 5 MC RANGE dial to ± 2.5 MC to determine the 5 MC sweep width. If necessary, adjust the 5 mc CENTER FREQ screw-driver control.

(e) Using the HP Model 612A tuned to approximately 1150 MC, tune the signal in with the TUNING knob on the Tuning Head.

(f) Adjust the signal generator output and GAIN control to give a full scale signal pip with about $1/32''$ of noise on the baseline with the AMPLITUDE SCALE switched to LIN position.

(g) Slowly tune the signal generator so that the signal travels across the Indicator screen. With the signal generator output kept at a constant level the response level should not vary more than $\pm .5$ db across the bandwidth.

(h) If the response is not flat or is tilted more than specified, it will be necessary to touch up the narrow-band filter (FL403), trimmers L441, L440, and L439 until a satisfactory result is obtained.

(i) Remove the signal from the DIRECT INPUT and connect a 50 ohm termination or any pad in its place. Press RANGE button #2/1.

(j) Turn the TUNING knob slowly through the 10-20 mc points on the dial scale. If a spurious signal appears approximately at the 13.5 mc point, it will be necessary to touch up the band pass filter (FL401) trimmers L437 and L438 until the signal disappears or drops into the noise.

(k) Check sensitivity in the same manner as in the wide-band i-f amplifier. The sensitivity specification at this check is better than -100 dbm.

n. SERVICING HINTS FOR THE 160 Mc IF AMPLIFIERS.

Any indication other than those described in the above sub-paragraphs is a sign of trouble. Each symptom should be treated before proceeding to the next step.

All the wide-band i-f amplifier stages in the SPA-4a Spectrum Analyzers through serial no. 200 are of the distributed amplifier type which is essentially a flat untuned line with all tubes in parallel and the LC circuits in series. Therefore a dip or peak in the response curve indicates an undesirable resonant stage.

In serial nos. 201 and up, the wide-band i-f amplifier stages are of the grounded grid type with all tuning stages as a complex impedance network. Therefore, any one trimmer will have a broad effect on the entire network. All the pre-amplifiers are also of the grounded grid type.

1. If in paragraph j.1.(e), trouble is encountered in getting the results shown in Fig. V-15, check for defective components in the amplifier stages.

2. In paragraph i.3.(b), if the proper curve shown in Fig. V-14a cannot be obtained, check for a defective or detuned filter FL401.

3. In paragraph i.3.(d), if the proper curve shown in Fig. V-14b cannot be obtained check for defective or detuned filter FL403.

4. In paragraph i.(e) if final results of Fig. V-14c cannot be obtained, check for defective cables or trouble in the narrow band amplifier.

5. If trouble is encountered in obtaining sweep linearity for narrow-band amplifiers, check all voltage supplies, both ac and dc filaments, B+ and sawtooth voltage input. Also check the sweep section including V804, V805 and V806.

6. If trouble is encountered in obtaining the response shown in Fig. V-13c for either narrow or wide-band operation, check switch K401 for continuity or for defective cables.

7. If the response shown in Fig. V-15 cannot be obtained, check the condition of tubes V405 and V406, or components and +200 V line.

8. If the marker cannot be centered as described in paragraph j.1.(h), check the setting

of the H POS control on the front panel, or C618 located on the rear of the wide-band chassis (access through button-hole). Check the sweep circuit of the wide-band which includes, V601, V603, V605 and/or increductor L601, or varistor RV601. Also check dc filament line and -150 V bias line.

9. If the flat response required in paragraph j.2(e), (f) and (g) cannot be obtained, check condition of K401.

10. If the final response curves for either narrow-band or wide-band operation cannot be obtained from the DIRECT INPUT jack, continuity check through all components in the input mixer, Z304, matching transformer (Z309) rotary co-ax switch S307, S308 and S309 and K401.

b. MARKER OSCILLATOR ALIGNMENT AND CHECK.

The MARKER dials of both the 5 MC RANGE and 70 MC RANGE have been individually calibrated and engraved at the factory. Should it ever become necessary to replace V700 or V701 because of tube failure, a carefully selected tube must be used for replacement or a correction table for the dial calibration must be prepared. This is especially true when replacing V701 (6J6).

A crystal controlled oscillator such as a Measurements Model 111 or a Hewlett-Packard Generator Model 608D should be used for this operation.

1. Zero Calibration Check. The only adjustment necessary for the 70 MC RANGE dial ± 40 is to center the "0" mark. This is automatically attained during the calibration of the 5 MC RANGE dial (± 3).

(a) Feed a calibrated 160 mc signal into the r-f DIRECT INPUT jack on the tuning head. Depress the 4/3 RANGE button. Turn the SWEEP WIDTH RANGE switch to the 0-5 MC position (narrow-band).

(b) Adjust the MARKER dials so that both "0"s center on the hairline.

(c) Adjust the MARKER LEVEL control so that a marker pip appears on the screen. If the calibration is correct, both signals will be superimposed. By careful adjustment of the GAIN, MARKER LEVEL and SWEEP WIDTH CONT controls, and with proper attenuation of the 160 MC calibrating signal, a "birdie" should appear on the Indicator screen. This indicates a zero beat and that the calibration for "0" is correct.

2. Zero Adjustment (C704). If the "0" is not correct, (the two signals do not coincide), it will be necessary to adjust the piston trimmer, C704.

(a) Remove the knob and potentiometer lock nut from the CENTER FREQ control and move the dual potentiometers which are located directly behind the panel, out of the way.

CAUTION

Be sure that these dual potentiometers (fine CENTER FREQ controls) do not short to the chassis.

(b) Insert a plastic screwdriver, such as Walsco #2519 or #2541, into the adjustment hole in the top of the marker oscillator casting and adjust the C704 trimmer until the two pips coincide and zero beat.

(c) Replace the dual potentiometers.

3. 5 Mc Range (± 3 MC) Calibration Check. When the dial zeros are adjusted, the calibration of the 5 MC RANGE dial may be checked.

(a) Turn the SWEEP WIDTH CONT control fully clockwise and inject 1 mc marker pips from the crystal calibrator or tune the generator exactly 1 mc away from 160 mc.

(b) Turn the 5 MC RANGE dial so that the marker pip moves slowly to the first calibration pip. When the two pips coincide, the #1 on the dial should be directly under the hairline index. The tolerance is ± 50 KC or $\pm 1/5$ of a dial division.

(c) Repeat steps 1 and 2 for all numbered divisions on the dial. All calibration checks are made by turning the dial AWAY FROM "0" to the division mark being checked.

(d) If calibration pips can be obtained for the subdivision marks (250 KC), check these in the same manner.

4. 70 MC RANGE (± 40 MC) Calibration Check. This range is a coarse tuning control for the marker oscillator. After the 5 MC RANGE dial has been calibrated, the 70 MC RANGE dial may be calibrated.

(a) Turn the SWEEP WIDTH RANGE switch to 0-70 Mc (wideband) position. Turn the SWEEP WIDTH CONT control fully clockwise.

(b) Set both dials on "0" and inject 10 mc marker pips from the crystal calibrator, or tune the generator exactly 10 mc away from 160 mc.

(c) Turn the 70 mc RANGE dial so that the marker pip moves slowly to the first calibration pip. When the two pips coincide, the #10 on the dial should be directly under the hair-line index. The tolerance is 200 KC or $\pm 1/5$ of a dial division.

(d) Check the calibration of all numbered divisions. All calibration checks are made by turning the dial AWAY FROM- "0" to the division mark being checked.

5. Replacement of V701. As stated previously, when replacing defective tubes, any gm or interelectrode capacitance difference between the original tube and the replacement may cause the loss of dial accuracy.

(a) Upon installation of a new tube, be sure that the tube shield is mounted on the tube.

(b) Proceed with the alignments and checks given in paragraph 1, 2, 3 and 4 above. Repeat these operations until a tube is found which will track as near as possible to the dial tolerances. A labor saving hint is not to re-install the CENTER FREQ dual pots until a good tube is found.

p. CRT POWER SUPPLY.

This is an r-f oscillator type of high voltage supply using a fly-back transformer. Corona effect which may be brought on by an accumulation of dust or corrosion causes most of the breakdown in this unit. The oscillation frequency of the circuit is approximately 90 kc.

Voltages and resistances are given in the Voltages and Resistance Chart at the rear of this manual. Trouble-shooting the unit is simple and straightforward and requires no explanation to an experienced technician.

The 90 kc modulation may feed through the +200 and +300 volt power supplies to the i-f amplifiers and may appear as a spurious modulation on the marker and signal pips. If it becomes objectionable, check the condition of L811, (2.5 mh) in the narrow-band i-f amplifier, it may have shorted turns.

1. Removal of sub-chassis. Instructions for the removal and replacement of the sub-chassis are given to prevent possible damage to the unit and its surrounding components.

(a) Remove the plate caps from V103 and V104 (6146), taking care not to break the 430 ohm resistors located in the caps.

(b) Loosen the two captive fasteners located on the left side of the high-voltage cage and free the slotted flap on the right side of the cage from the retaining stud.

(c) Open the side door which mounts the wide-band and narrow-band amplifiers and swing it as far open as possible. This will provide working room and clearance for removal of the cage.

(d) Carefully work the cage forward and downward until the CRT power supply sub-chassis is cleared.

(e) Disconnect the cathode and accelerator cables from the CRT. Disconnect the power cable from J117 mounted on the top rear of the analyzer frame.

(f) Unfasten the mounting screws from the four insulating posts that mount the sub-chassis to the frame and lift out the unit.

(g) Replace the unit in the reverse order.

V-4. SERVICE, MAINTENANCE AND ALIGNMENT PROCEDURE, COMPOSITE TUNING HEAD, MODEL RF-4a

a. GENERAL.

This section contains adjustment, alignment and replacement procedures which may become necessary because of the aging or failure of any of the tubes or components used in the composite Tuning Head, Model RF-4a.

There are several points of difference between production runs of the Model RF-4a. Where the difference warrants, alternative procedures are given.

b. REMOVAL OF TUNING HEAD FROM ANALYZER FRAME.

For some component alignment, adjustment or replacement procedures it may be necessary to remove the Tuning Head from the analyzer frame. Removal of the Tuning Head will be specified when required. For instance, it is not necessary to remove the Tuning Head from the frame in order to align and/or calibrate any of the local oscillators.

1. Removal.

(a) Loosen the four captive thumb screws on the front panel and pull the Tuning Head out as far as it will go.

(b) Remove all connecting cables from the Tuning Head to the analyzer chassis. (Three power cables and four coaxial cables).

(c) Remove the retaining screw from the stop bracket mounted on the rear end of each of the two drawer slides, and pull the Tuning Head completely out of the analyzer. The slides ride on ball bearing clips which may fall out if care is not taken when performing this step.

2. Replacement.

(a) To replace the Tuning Head, face it from the front and grasp both slides near the rear.

(b) Push the ball bearing retainer clips toward the rear or leading end of the slides, then rock the Tuning Head into the mating slides on the analyzer frame until the Tuning Head clears and rolls into place.

(c) Fasten the two stop brackets into place. Pull the Tuning Head outward until the bearing retaining clip snaps into place. Roll the Tuning Head in and out to check for free and clear rolling action.

(d) Connect the three power cables. Connect the four coaxial cables. The coaxial cables have reference tags and are coded with colored dots to aid in making the proper connections.

c. PRELIMINARY RESISTANCE AND MECHANICAL CHECK.

This sub-paragraph is presented as an aid to troubleshooting the Tuning Head, so that a malfunction during operation may be localized. Refer to the Troubleshooting Chart and to the appropriate sub-paragraph, if necessary, for more detailed instructions in repairing the components found to be defective.

1. General. These measurements are not available in the Voltage and Resistance Chart. All these measurements are made to chassis ground with the power cables disconnected from J301, J303, J305, J401 and J405, which are located on the pre-amplifier chassis.

(a) Turn the POWER switch to the ON position.

(b) Set the RANGE switch buttons to "Standby" position (all out).

(c) Set the METER FUNCTION switch to +200 V position.

2. Input Cabling Resistance Measurements.

(a) J301: Pin 1 to pin 4 = 0 ohms
Pin 2 to pin 3 = 0 ohms
Pins 1, 2, 3, 4 and 5 = open to ground
No connections (open) between pins 1 and 4 to 2 and 3.

(b) J303: Pin 1 = 0 ohms
Pin 2 = 3.9 ohms
Pin 3 = open
Pin 4 = 20 K
Pins 5, 6 and 7 = open
Pins 8, 9, 10, 11 and 12 = open
Pin 13 = approximately 10 ohms
Pin 14 = 0 ohms
Pin 15, 16, 17, 18 and 19 = open
Pin 6 to 7 and pin 17 to 18 = 0 ohms when the Range switch is in any position except 2/1 and "Standby".
Pin 16 to 19 = 0 ohms when Range switch is in 4/3 position only.

(c) J305: Pin 1 = 0 ohms
All other pins read open to ground.

(d) J401: Pin A to pin 1, S305B (top half of METER FUNCTION switch) = 0 ohms
Pin A to pin 1, S305A (Lower half of METER FUNCTION switch) = 75 ohms
Pin B to Pin 15, J303 = 0 ohms
Pin H = 0 ohms
Pin D = NC (open)
Pin E to pin 4, J303 = 0 ohms.

3. RF ATTENUATOR Resistance Check.

The attenuator is not calibrated in DB. The dial divisions are used for reference only. There is an insertion loss ranging from approximately 12 db to 35 db dependant on input frequencies. However, once allowance for the insertion loss is made, the dial scale will indicate a ratio of approximately 10:15 on the 10 - 1000 MC range and about 10:11 on the 1-11 KMC range.

If the attenuators are suspected of being defective, the only check that may be made in the field is a resistance check from the center pins of the Type "N" fittings on the front panel of the Tuning Head to ground. They are rated at 1/8 watt and may be burnt out if signals greater than +24 dbm are applied to the attenuator input.

When the resistance check is being made, rotate the dial knob back and forth to check for intermittent shorts or opens.

- (a) 10 MC - 1 KMC ATTEN OUTPUT = 0 ohms (resistor in shunt with coil)
- (b) 10 MC - 1 KMC ATTEN INPUT = 50 ohms (resistor in series with coil)
- (c) 1 - 11 KMC ATTEN OUTPUT = 50 ohms
- (d) 1-11 KMC ATTEN INPUT = 50 ohms

4. Removal and Replacement of the RF Attenuator Assembly (Reference Figure V-39). If removal of the RF Attenuator assembly is necessary, use with the following procedure.

- (a) Set the RF Attenuator dial to zero.
- (b) Remove the RF Attenuator knob.
- (c) Remove the mounting screws which hold the 1-11 KMC ATTEN. INPUT and ATTEN. OUTPUT connectors in place (Fig. V-39, ref. 5 and 6).
- (d) Remove the mounting screws which hold the 10 MC - 1 KMC ATTEN. INPUT and ATTEN. OUTPUT connectors in place (Fig. V-39, ref. 1 and 2).
- (e) Remove the RF Attenuator assembly mounting screw, located on the right-hand side of the RF Attenuator knob, on the front panel.
- (f) Remove the entire RF Attenuator assembly up and out of the Tuning Head.

To replace the RF Attenuator assembly, reverse the above procedure.

5. Alignment of the RF Attenuator Assembly. (Reference Figure V-39.) The alignment of the RF Attenuator assembly should be done with the entire assembly removed from the Tuning Head.

- (a) Connect a signal generator, set at 500 MC, to the DIRECT INPUT connector of the SPA-4a, with all controls as described in section III-1b (MARKER--OFF).
- (b) Rotate the TUNING knob until the 500 MC signal appears at the center of the Indicator screen.
- (c) Disconnect the signal generator from the DIRECT INPUT connector, and connect it to the 10 MC - 1 KMC ATTEN. OUTPUT connector (Fig. V-39, ref. 1)

(d) Connect a jumper cable from the 10 MC - 1 KMC ATTEN. INPUT connector (Fig. V-39, ref. 2) to the DIRECT INPUT connector on the SPA-4a.

(e) Hold the dial (Fig. V-39, ref. 3) at the zero position (fully clockwise).

(f) Loosen the setscrew (Fig. V-39, ref. 4) of the low frequency spur gear and move the spur gear off the rack until the Low Frequency Barrel moves freely.

(g) Move the Low Frequency Barrel until a maximum signal amplitude is indicated on the CRT screen.

(h) Move the low frequency spur gear back onto the rack and tighten the setscrew. A zero dial reading should show maximum signal amplitude on the Indicator screen.

(i) Remove all connections and insert a 5000 MC signal to the DIRECT INPUT connector of the SPA-4a.

(j) Rotate the TUNING knob until the signal appears at the center of the Indicator screen.

(k) Disconnect the signal generator from the DIRECT INPUT connector and connect the 5000 MC signal generator signal to the 1-11 KMC ATTEN. OUTPUT connector (Fig. V-39, ref. 5).

(l) Connect a jumper cable from the 1 - 11 KMC ATTEN. INPUT connector (Fig. V-39, ref. 6) to the DIRECT INPUT connector of the SPA-4a.

(m) Loosen the setscrew (Fig. V-39, ref. 7) of the High Frequency Probe and twist the High Frequency Probe (Fig. V-39, ref. 8) until maximum signal is indicated on the CRT screen. The High Frequency Probe should be pushed completely into its barrel during this adjustment.

(n) Tighten the setscrew of the High Frequency Probe. A zero dial reading should show maximum signal amplitude on the Indicator screen.

6. Repeller Tracking Potentiometer and Mode Switching Cams. This check is made when troubleshooting a suspected malfunction of a klystron cavity. The information contained in this sub-paragraph is presented at this time because it concerns the alignment of the dual tracking potentiometer by means of resistance measurements.

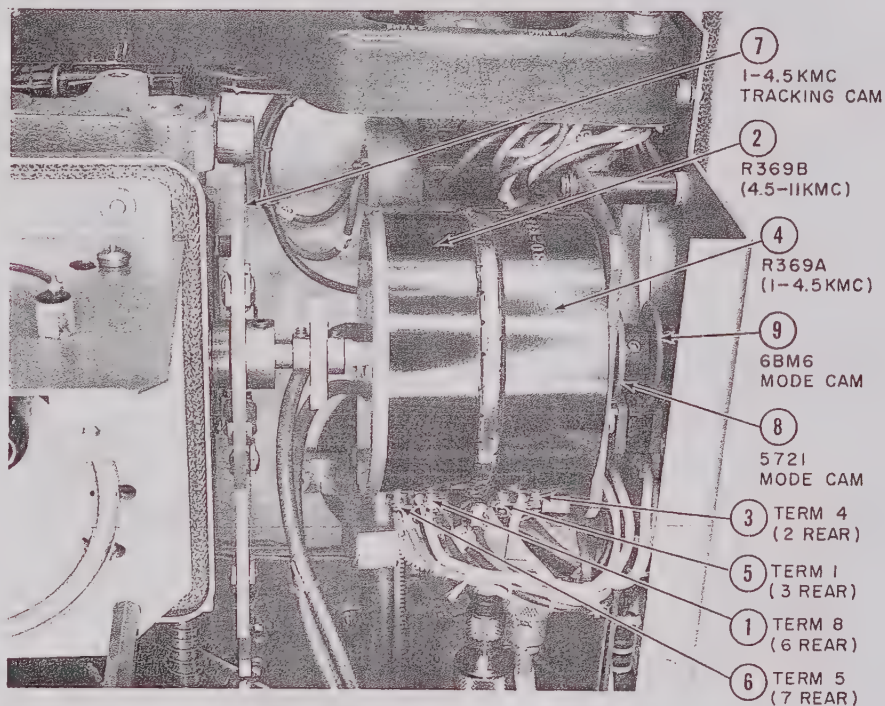


Figure V-18a. Repeller Tracking Potentiometer (Ser. Nos. 151 - 250)

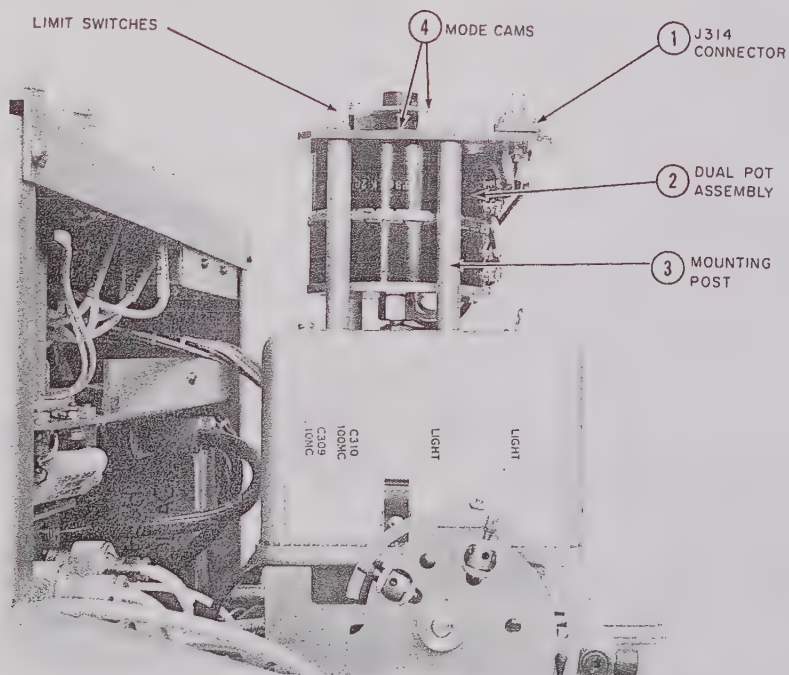


Figure V-18b. Repeller Tracking Potentiometer (Ser. Nos. 251 - up)

The cavity mode switching cams are also aligned during this operation. These two checks are also made when checking the alignment and calibration of a klystron cavity. (See par. V-4.f).

The dial pointer must be correctly set. This is checked when RANGE #1 is calibrated. (See par. e.4).

(a) Repeller Tracking Potentiometers.

(1) Connect an ohmmeter between terminals 6 and 8 (Ref. 1., Fig. V-18) on R369B, the 4.5-11 kmc tracking potentiometer (Ref. 2, Fig. V-18) Turn the TUNING knob until a reading as close to zero as possible is reached. The dial scale should read 7850 ± 50 MC on RANGE #5.

(2) Connect the ohmmeter between terminals 2 and 4 (Ref. 3, Fig. V-18) on R369A, the 1-4.5 kmc tracking potentiometer (Ref. 4, Fig. V-18). Then turn the TUNING knob until a reading as close to zero as possible is reached. The dial scale should read 1440 ± 15 MCS.

(3) Check the resistance winding for smooth tracking and/or open windings.

After the zero point has been checked, connect the ohmmeter leads between terminals 1 and 2 of R369A (Ref. 3, 4, and 5, Fig. V-18) and slowly rotate the TUNING knob from the low frequency (left) end of the dial across the entire scale. The resistance should start somewhere between 0 and 500 ohms and increase smoothly without jitter to the cross-over point where it will fall back and then continue to climb until approximately 160 K ohms is reached.

Perform the same check for R369B (Ref. 2, Fig. V-18); connect the ohmmeter leads between terminals 5 and 6 (Ref. 1, 6, Fig. V-18) and proceed as above.

(4) If the zero reading cannot be obtained at the proper dial frequency reading, it will be necessary to loosen the shaft coupling at the slide nearest the 1-4.5 kmc klystron cavity tracking cam (Ref. 7, Fig. V-18) then rotate the coupling slowly until the zero reading is reached. This alignment step is required for only one section of the tracking potentiometer because the other section will fall in automatically. If both sections do not reach their zero points within tolerance, the potentiometer must be removed and repaired. (See par. 4(d) below).

Tighten the set-screws before proceeding further.

(b) Mode Switching Cams (5721)

(1) Set the TUNING dial to 7850 mc. Observe the 5721 cam and microswitch (S306). It should be at its switching point. As the dial is tuned toward the right (high end), the mode cam (Ref. 8, Fig. V-18) should press the microswitch plunger in and keep it closed until the end of dial travel is reached.

Return to the switching point and check to see that the cam releases the plunger and remains open until the low frequency end of the dial travel is reached. When the switching point is crossed from high to low, two distinct clicks should be heard. When crossing from low to high, one distinct click is heard. The differential for single click is ± 50 mc.

(c) (Mode Switching Cam (6BM6)

(1) The method of checking the 6BM6 mode switching cam Ref. 9, Fig. V-18) and microswitch S303 is the same as for the 5721 mode switching cam. In this step, the dial frequency is 1440 mc and the tolerance for the single click, when traveling from low to high frequency is ± 15 mc.

(2) If in either cam the two distinct clicks cannot be heard, it is an indication that the clearance between plunger and cam is incorrect. It will be necessary to reset the micro-switch mounting screws for correct clearance.

If the cam does not actuate the switch at the proper point, it will be necessary to reset the cam by loosening its set-screws and rotating the cam until the correct action is obtained at the frequency check point. Tighten the set-screws before proceeding further.

(d) Removal and Replacement of Dual Repeller Tracking Potentiometers. (Ser. No. 151-250, reference Fig. V-18a.) Should it become necessary to move the dual tracking potentiometer in order to replace the 1-4.5 kmc klystron cavity or to remove it because the dual potentiometer needs repair or replacement, proceed as follows:

(1) Remove the three mounting screws located on the side gusset. (Take note whether any fibre washers are used as spacers on any of the mounting posts, they will have to be replaced in their identical position when re-installing the dual potentiometers.

(2) Loosen the four set-screws on the shaft coupling and push the coupling as far as it will go on the steel shaft.

(3) Work the dual potentiometer outward until the nylon shaft is free of

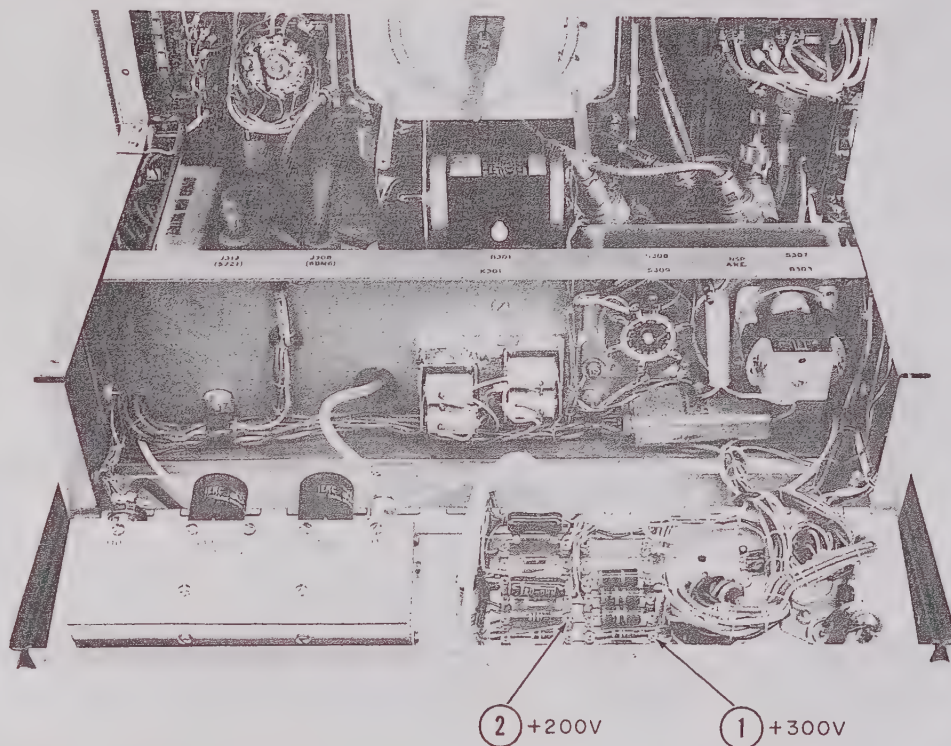


Figure V-19a. Tuning Head (Rear View) Ser. Nos. 151 - 200

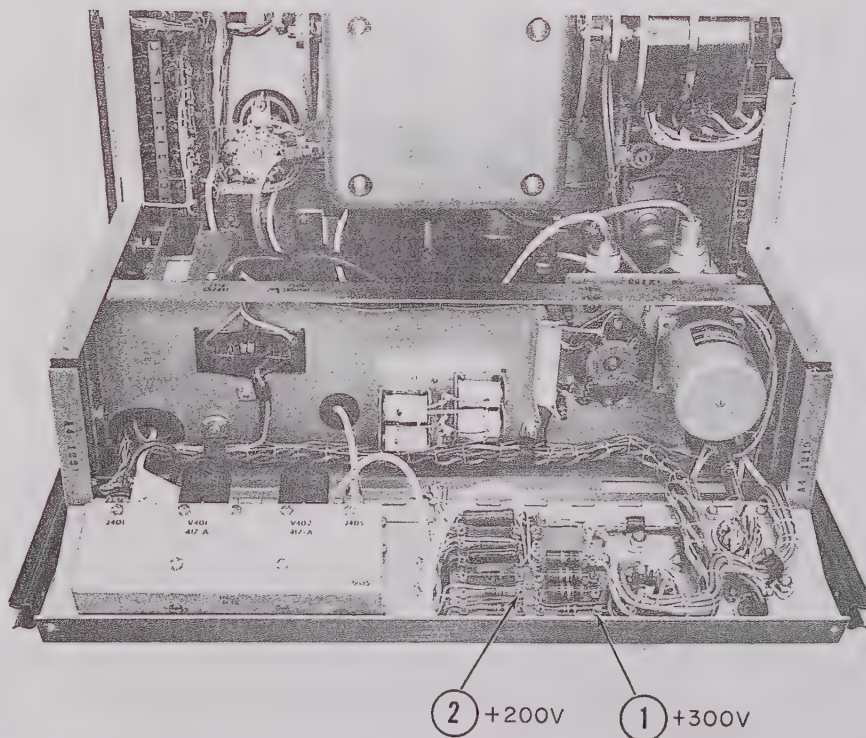


Figure V-19b. Tuning Head (Rear View) Ser. Nos. 201 - 250

the coupling. The side gusset may have to be pulled back in order to obtain sufficient clearance. Take care not to put excessive strain on the nylon shaft. Move the dual potentiometer outwards and from its location.

(4) Only steps (1), (2) and (3) are required when replacing the 1-4.5 kmc klystron cavity.

(5) If the dual potentiometer needs repair or replacement, tag its leads before disconnecting.

(6) Replacement of the dual potentiometer requires reversing the preceding steps (1), (2), (3), (4) and (5) and its realignment. Refer to paragraph (a) above.

(e) Removal and Replacement of Repeller Dual Tracking Potentiometers. (Ser. Nos. 251 and up) Reference Fig. V-18b.

(1) Remove connector J314.
(Ref. 1).

(2) Remove the gray Tracking Potentiometer cover by unscrewing the two mounting screws on the rear of the cover, then pull the cover straight back and out.

(3) Remove and tag all connecting wires on the dual potentiometer assembly.
(Ref. 2).

(4) Remove the four screws which hold the mounting plate to the four mounting posts. (Ref. 3).

(5) Loosen the four Mode Cam set-screws and remove the Mode Cams from the nylon shaft. (Ref. 4)

(6) Remove the three screws which hold the dual potentiometer assembly to the mounting plate.

(7) The dual potentiometer assembly is now free for removal and replacement. Refer to section V-4 g and h for Alignment and Calibration of the Cams and Tracking Potentiometers.

d. ELECTRICAL CHECK.

1. General. Upon completion of the resistance check and any adjustments that were found to be necessary, the Model RF-4a Composite Tuning Head is ready to be connected to power.

WARNING

A dummy load is required to check the klystron filament supply and also for use whenever one of the klystron tubes is disconnected from J308 and/or J312. This is required in order to protect the zener diodes CR305 and CR311 from overload. The dummy load consists of 10 ohm, 20 watt resistors connected across socket pins 2 and 4 of J308 and J312. All that is basically necessary is for the leads of the load resistors to be inserted into the socket pins, but it is more convenient to mount the resistors in a 4 pin mating plug for the sockets.

(a) Set the POWER switch to OFF, Connect J301, J303, J305, J401 and J405 to their mating plugs and cables. Be sure that J308 and J312 have the dummy loads.

(b) Set the RANGE switch push buttons to "Standby" position (all buttons out.) Connect the a-c power cord to J101 and adjust the a-c line to 115 VAC.

2. Metering Circuit. Set the toggle switch to POWER and check that the POWER indicator lamp glows.

(a) Turn the METER FUNCTION switch to +200 V position and note that the meter reads approximately 1/2 scale. Switch to the +300 V position and the meter should again read 1/2 scale. If the meter indicates less than .4 or more than .6 for either setting, check the power supply voltages at the check points, Ref. 2 and 4, Fig. V-5.

Continuity check the wiring from Ref. 1 and 3, Fig. V-19a or V-19b for the +300 V line and Ref. 2 and 4 for the +200 V line. Continue on through the meter circuit until the trouble is found. The meter is located at the grounded end of the line and the voltage drop across it is about .05 V.

(b) Press the RANGE 2/1 button and turn the METER FUNCTION switch to CRYSTAL BIAS position. The meter needle should deflect to some degree. (This reading is dependent upon the setting of the CRYSTAL BIAS ADJ pot, RANGE 1, 2).

A further check of this circuit requires pressing the XTAL CURRENT button. The meter reading at this time indicates the oscillator output power at dial frequency. If the current is too weak, the needle may not deflect. This is not necessarily an indication of trouble. There is the possibility that the oscillator power output may be greater at some other frequency point. Tune

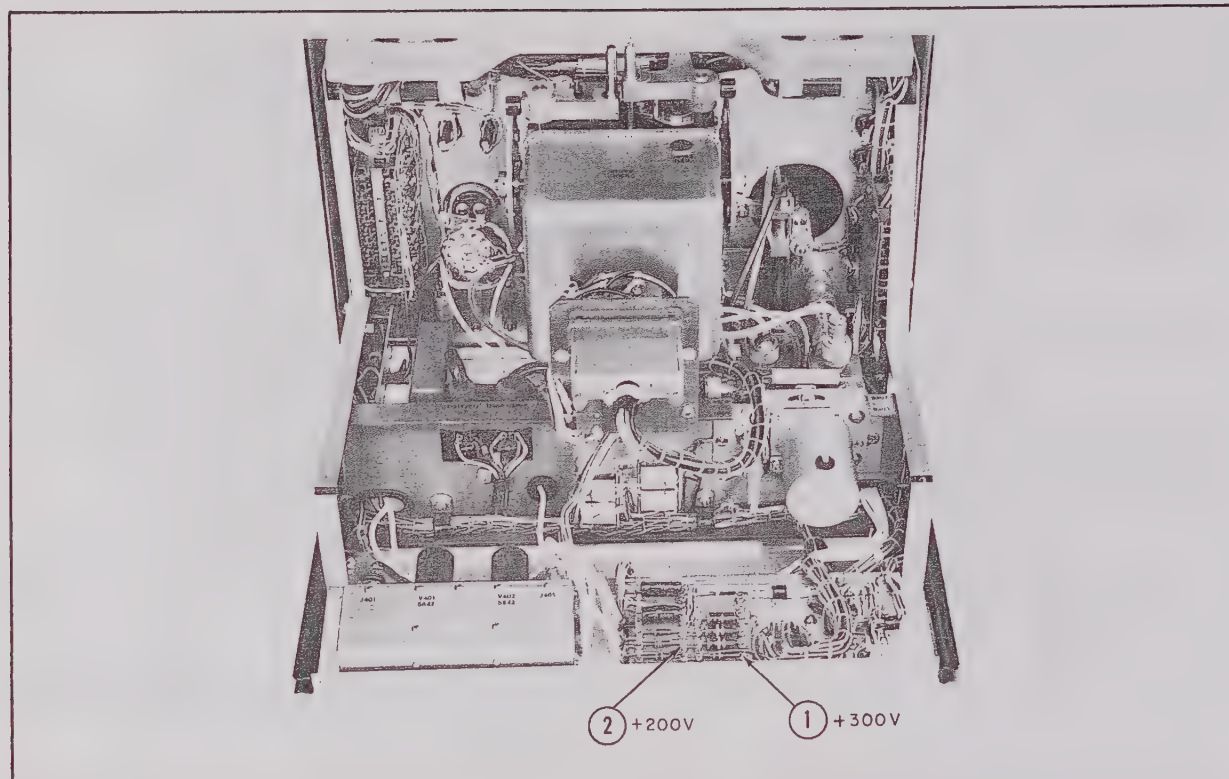


Figure V-19c. Tuning Head (Rear View) Ser. Nos. 251 - up

through the TUNING dial scale until a readable deflection is attained.

If no deflection can be obtained in either position of the XTAL CURRENT button, it is an indication of an open or short circuit in the r-f input line. Check the condition of the crystal mixer CR313 (1N358A). Check that all r-f connections are tight and in good condition. Repeat this check through all the RANGE button positions.

If the meter needle deflects violently to the right, adjust the CRYSTAL BIAS potentiometer for the pertinent RANGE position until the needle returns to the middle of the meter scale. The r-f input sensitivity for that range will also have to be checked and adjusted (see par. V-3.1 and m) If the needle deflects violently to the right when the XTAL CURRENT button is depressed, in any RANGE position, it could also be an indication of an open resistor in the oscillator output circuit, such as, R355, R359, and R375 (50 ohms).

(c) Press the RANGE #4/3 button and turn the METER FUNCTION switch to KLYSTRON CURRENT position. After 5 seconds delay the meter needle should deflect to approximately .4 (20 ma) on the scale. If a reading higher than .6 (24 ma) appears, the CURRENT potentiometer on the 6BM6 OSC ADJ board may be turned too far clockwise. If the current reading cannot be

brought down, there may be trouble in the 6BM6 klystron circuit (see par. V-4.d.3,4).

(d) Turn the METER FUNCTION switch to the CATHODE V and REFLECTOR V positions. The meter should indicate approximately 1/2 scale. If the meter reading is less than .4 or more than .6 check the klystron power supply. Voltage at Ref. 5, Fig. V-5 should be -925 vdc; at Ref. 11, the voltage should be -325 vdc. These voltages should appear through the closed contacts of K113. Dirty or corroded contact points will cause a drop in cathode and reflector voltages to the 6BM6 klystron tube and metering circuit.

(e) Pressing any RANGE button from #5 to #8 should also cause the meter to read between .4 and .6 (20 and 24 ma) when the METER FUNCTION knob is set to KLYSTRON CURRENT. In those ranges, the 5721 klystron is operated and the 5721 OSC ADJ CURRENT potentiometer will control the amount of klystron beam current.

(f) Turn the METER FUNCTION switch to CATHODE V and REFLECTOR V. When any of the RANGE #5 to #8 buttons are depressed the meter will indicate approximately 1/2 scale. If the meter reading is less than .4 or more than .6, check the klystron power supply voltage. At Ref. 5, Fig. V-5 it should measure -1850 vdc, and

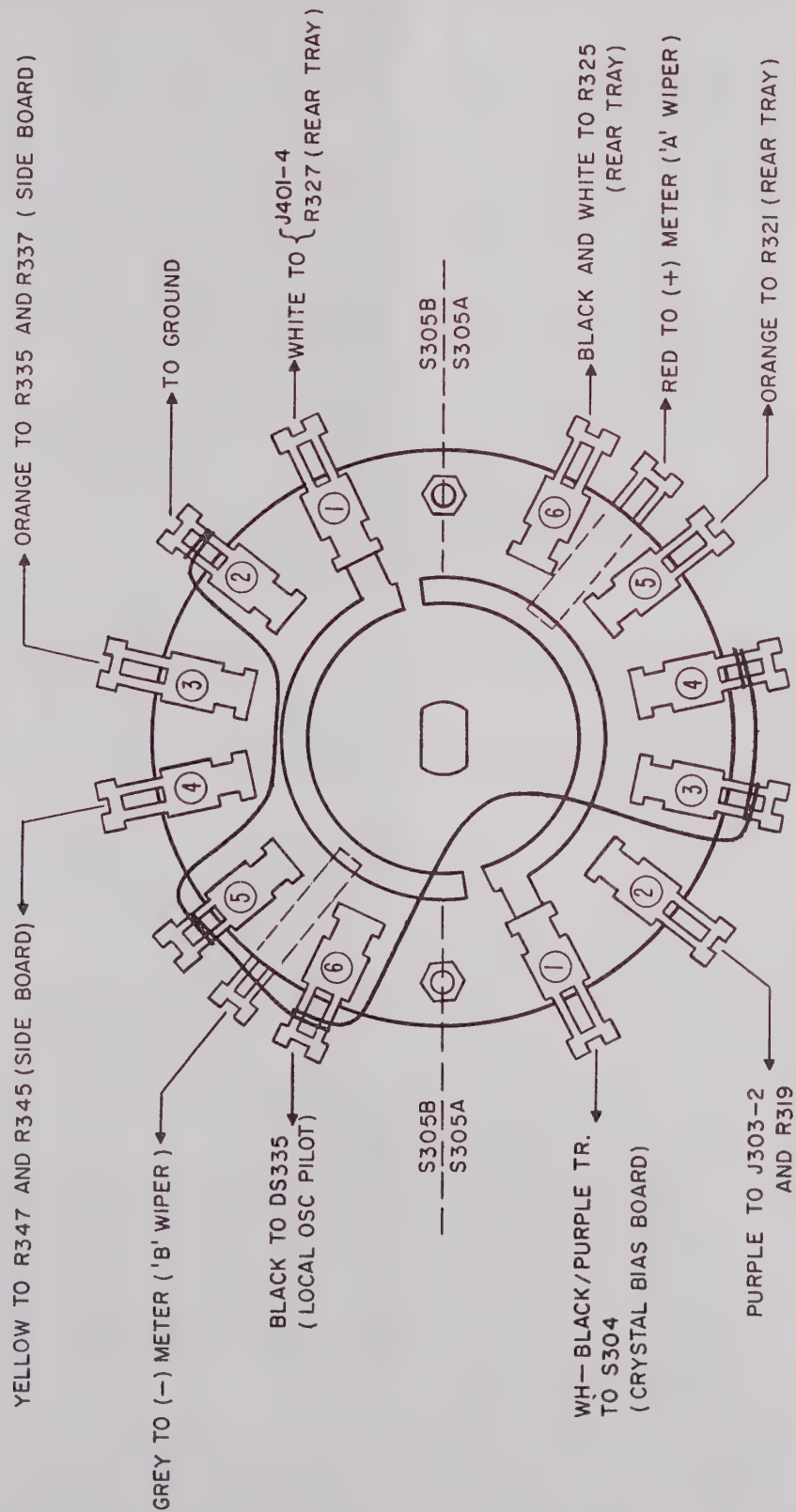


Figure V-20. Meter Function Switch (Wiring Diagram)

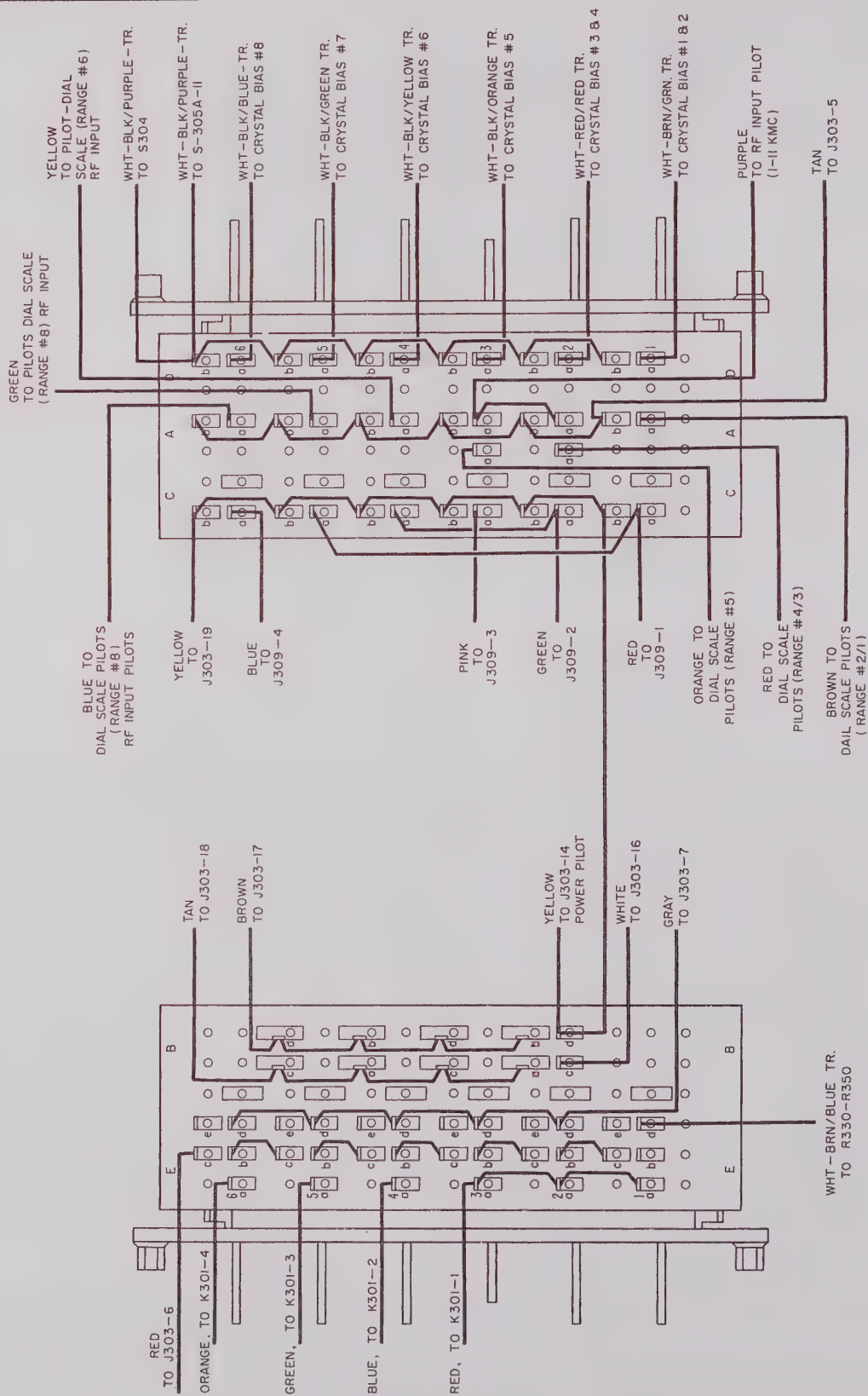


Figure V-21. Range Pushbutton Switch (Wiring Diagram)

at Ref. 7 the voltage should measure -1250 vdc. These voltages should appear through the closed contacts of K113. Dirty or corroded contact points will cause a drop in cathode and reflector voltages to the 5721 klystron tube and metering circuit.

3. Klystron Filament Supply. Both of the klystron filaments are heated by a regulated dc supply. These units are located on the lower right side of the Tuning Head and are mounted on the gusset by insulating spacers. Some units may be equipped with additional spacers for the protective cover. This is to provide better ventilation and has no bearing on the electrical characteristics of the unit. See Figure V-19a and b.

(a) Reset the RANGE switch to "Stand-by" position (all push buttons out) and measure the voltage across socket pins 2 and 4 of J308 and J312. They each should read 6.3 vdc (pin 2 is negative).

Ripple voltage across pins 2 and 4 of each socket should be:

105 VAC INPUT = approx. 150 mv

115 VAC INPUT = approx. 60 mv

125 VAC INPUT = approx. 60 mv

Return to 115 VAC line input.

(b) Push in RANGE #4/3 button. After 5 seconds, operating voltages will appear at J308. Pin 3 should read -325 V. Pins 2 and 4 ride on -325 volts.

Using a VOM, place the positive lead on pin 1 and the negative lead on Pin 3. Turning the 6BM6 OSC ADJ CURRENT potentiometer should cause the voltage to vary between 0 and 15 volts.

(c) Push in RANGE #5 button. Pin 3 of J312 should read -1250 V. Pins 2 and 4 ride on -1250 volts.

Using a VOM, place the positive lead on Pin 1 and the negative lead on Pin 3. Turning the 5721 OSC ADJ CURRENT potentiometer should cause the voltage to vary between 0 and 40 volts.

4. Repeller Tracking Potentiometer and Mode Switching Cams. After the resistance checks have been made and the dual repeller tracking potentiometers have been aligned as described in paragraph c.6 above, a check must be made to see that proper operating voltages will be supplied to the klystrons. This check is made with the dummy loads in klystron sockets J308 and J312.

(a) 6BM6 OSC ADJ Potentiometer Board.

(1) Set all the 6BM6 OSC ADJ repeller adjustment potentiometers (0.9 KMC, 1.43 KMC, 1.45 KMC and 2.2 KMC) to the center

of their ranges. Set the tuning dial pointer to the extreme low end (left side) of the dial scale.

(2) Connect the positive lead of a VOM to the test jack 6BM6 "K" and the negative lead to the Red 6BM6 MOD test jack.

(3) Press the RANGE #4/3 button. After the 5 second delay, turn the TUNING knob slowly clockwise, the voltage should increase as follows:

From 125 V $\pm$ 20 to 270 V $\pm$ 20 at the switch point.

From 80 V $\pm$ 20 to 220 V $\pm$ 20 at the high end.

(b) 5721 OSC ADJ Potentiometer Board

(1) Set all the 5721 OSC ADJ repeller adjustment potentiometers (4.4 KMC, 7.83 KMC, 7.85 KMC and 10.9 KMC) to the center of their ranges. Set the TUNING dial pointer to the extreme low end (left side) of the dial scale.

(2) Connect the positive lead of a VOM to the test jack 5721 "K" and the negative lead to the 5721 red "MOD" test jack.

(3) Press the RANGE #5 button, then turn the TUNING knob slowly clockwise. The voltage should increase as follows:

From 90 V $\pm$ 20 to 510 V $\pm$ 20 at the switch point

From 100 V $\pm$ 20 to 275 V $\pm$ 20 at the high end.

5. Blower Fan Switch, S311 (Ser. #151-200). This microswitch is used to stop the klystron blower fan, B301, when the RANGE #4/3 button is pressed. The purpose of this action is to minimize vibration in the tuning head when the 6BM6 klystron tube is operating, so that incidental FM caused by microphonics is reduced.

If the blower fan does not stop when RANGE #4/3 button is pressed, or if the fan stops momentarily and then resumes when pressure is taken off the button; check the position of the switch mounting bracket. It may have loosened and changed the clearance distance between the switch actuator arm and the pushbutton switch bar when in position #2.

Reposition the mounting bracket for proper operation.

6. RANGE Pushbutton Switch (S302) and METER FUNCTION Switch (S305). These two switches may be serviced when necessary by referring to the wiring diagram Fig. V-20 and V-21. They are both of the sliding contact wafer type design. It is not feasible to repair these switches for defective or burnt contacts in the

field, but the switch must be replaced as a unit. However, there is one trouble that may develop because of frayed and loose wire matting of the Metex r-f shielding used in the installation of the pushbutton RANGE switch, S302. The loose ends may accidentally short some of the contacts nearest the Metex shielding.

(a) Removal and Replacement of S302.

(1) Place the klystron filament supply down and out of the way by removing its four mounting screws from the side gusset.

(2) Remove all the buttons from the switch.

(3) Remove the two mounting screws (spline socket button head) on the front panel, and back out the switch. (On serial nos. 151 - 250 it will also be necessary to remove the S311 mounting bracket.)

(4) Tag all leads before removing them from the pushbutton switch.

(5) Replacement of S302 is performed in reverse order. Take special care that the Metex shielding is replaced neatly and clear of the switch contacts.

(b) Removal and Replacement of the Meter Function Switch (S305).

(1) Tag all the switch lead wires and unsolder them from the switch lugs.

(2) Remove the locknut from the back of the meter knob drive stud and turn the placement nut forward to the panel as far as it will go without binding on the stud.

(3) Loosen the setscrews on the switch arm and move the arm forward on the shaft as far as it will go.

(4) Remove the shaft locknut and lock washers and pull the switch off the mounting bracket.

(5) To replace the switch, reverse the above procedure. When tightening the switch arm setscrews, check the position of the meter knob pointer to see if it coincides with the switch position.

(c) Removal and Replacement of the Panel Meter (M301). The panel meter contains a 1 ma movement and may be tested by removing the red and grey leads from the meter lugs and applying a 1 ma current by conventional methods.

One method is to connect the meter in series with a flashlight battery, a 1000 ohm resistor, a 1000 ohm variable resistor, and a calibrated milliammeter. Adjust the variable resistor until the milliammeter reads 1 ma. The pointer of the meter (M301) should deflect to the right and should indicate 1.0 ma $\pm 5\%$. To remove the meter, perform the following procedure.

(1) Remove the locknut from the meter knob drive stud. Disconnect the red and grey wire leads from the meter lugs.

(2) Turn the meter locknut counter-clockwise and remove it from the meter shell. At the same time, remove the placement nut from the drive stud so that the assembly will be free when it is removed from the panel.

(3) In serial nos. 151-250 the meter shell must be unscrewed from the front panel. Grasp the meter window retaining nut with the fingers of your left hand and the meter shell with your right hand and unscrew the meter out of the panel. If a strong enough grip cannot be obtained in this manner, it will be necessary to resort to tools, but care should be taken or the meter will be damaged beyond repair.

(4) The entire assembly including the meter knob and nylon washer bearings will now come loose. When replacing the meter, it will be expedient to file away the threads on the panel mounting hole and remount the meter as described in step (7) below.

(5) In serial nos. 251 and up, follow steps (1) and (2) above, then pull the entire meter and knob assembly out of the panel.

(6) Remove the locknut and nylon washer bearing from the meter shell and lift it out of the meter knob.

(7) When replacing the meter in units with serial nos. 151 and up, place a nylon washer bearing on the meter shell up against the window retaining-nut and insert the meter into the meter knob. Slide another nylon washer bearing on the meter shell and up against the back of the meter knob. Screw a meter locknut up against the bearing and tighten enough so that the knob turns snugly but freely on the meter shell.

(8) Insert the assembly into the panel mounting hole. When the meter knob drive stud appears through the curved slot of the panel, install the placement nut on the stud. Then align the stud into the switch arm. Fasten the meter shell with another locknut. Resolder the meter leads (red on (+), grey on (-)).

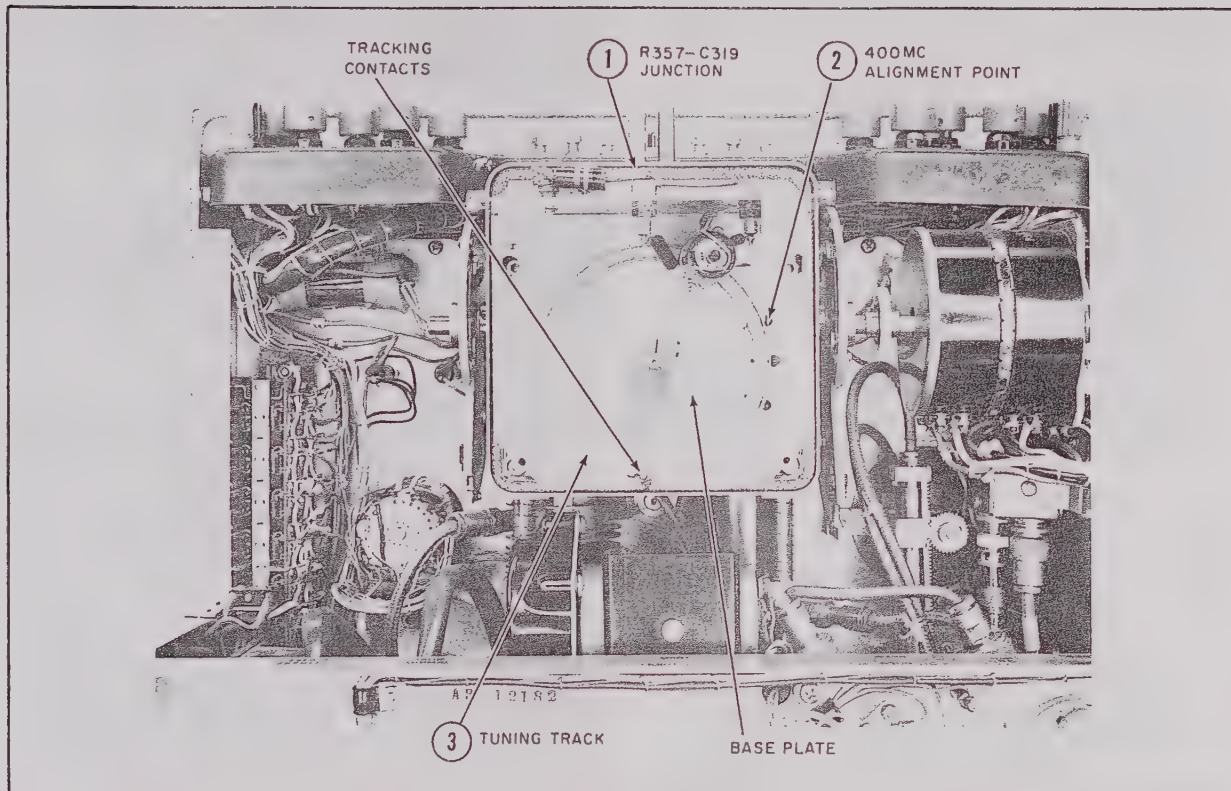


Figure V-22a. Triode Oscillator (Rear View) Ser. Nos. 151 - 250

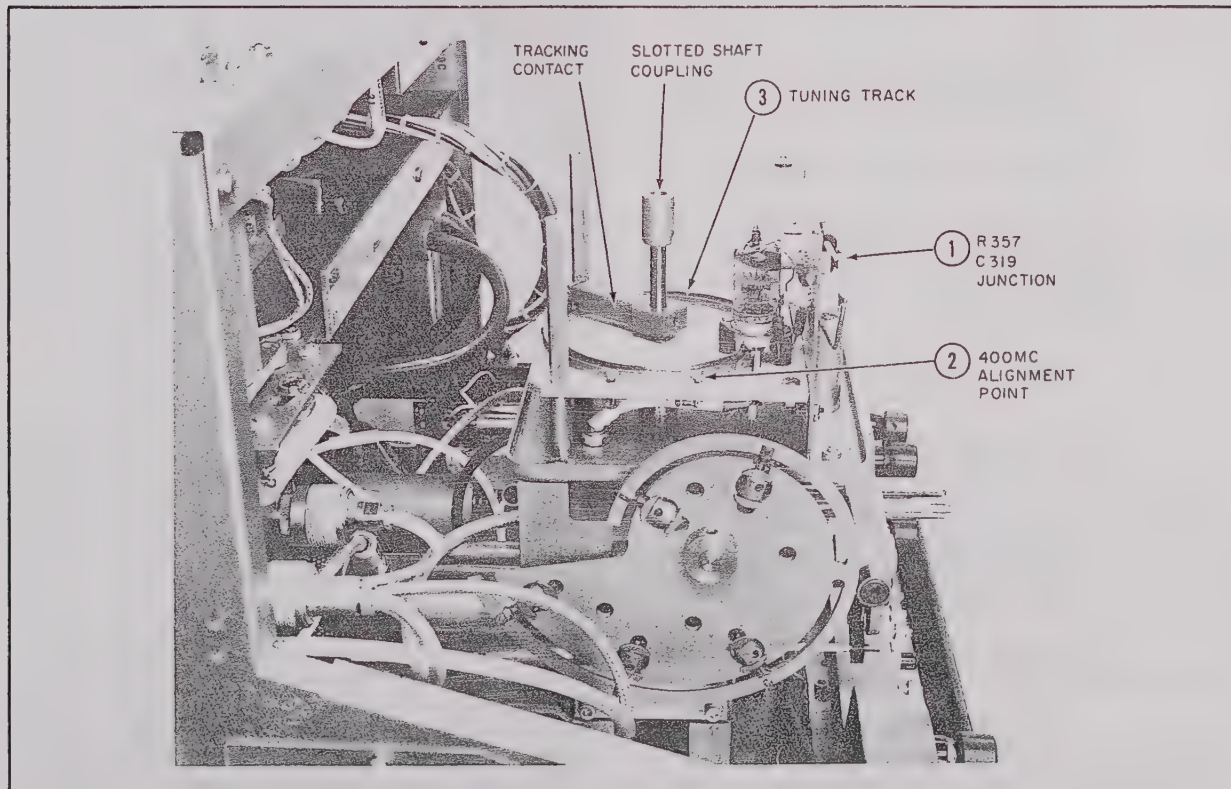


Figure V-22b. Triode Oscillator (Rear View) Ser. Nos. 251 - up.

e. TUBE REPLACEMENT AND ALIGNMENT OF TRIODE OSCILLATOR, V301.

A quick check to determine whether the triode oscillator tube needs replacement or the oscillator circuit needs repair is to measure the voltage at the junction of R357 and C319, Ref. 1, Fig. V-22a. Remove the oscillator cover, (see par. 1 (a) below) and depress RANGE #1 button. As the rotor arm is rotated through the range, the voltage at this test point should be approximately +35 volts; if the circuit is not oscillating the voltage will be approximately +25 volts.

1. Replacement of V301. (Ser. #151-250)

(a) Remove the triode oscillator cover by unscrewing the four mounting screws on the rear of the cover, then pull the cover straight to the rear. If the cover seems to catch and does not come off easily, remove the snap buttons from the side of the cover.

(b) The oscillator tube V301 will now be exposed for removal and replacement. Replace the cover by carefully fitting it into its groove and reinstalling the mounting screws.

As the screws are tightened, work the cover to fit correctly into its groove. Make sure the cover is not askew. DO NOT tighten the screws too much, the cover should fit snugly but not be forced in. Replace the snap buttons.

2. Replacement of V301. (Ser. No. 251 and up).

(a) Remove connector J314.

(b) Remove the gray Tracking Potentiometer cover by unscrewing the two mounting screws on the rear of the cover, then pull the cover straight back and out.

(c) Note the frequency setting of the dial pointer on the dial scale.

(d) Remove the triode oscillator cover by unscrewing the four mounting screws on the rear of the cover, then pull the cover straight back and out. Do not rotate the Tracking Potentiometer shaft without first taking note of the position of the mating ends of the Tracking Potentiometer slotted shaft coupling.

(e) The oscillator tube V301 will now be exposed for removal and replacement.

(f) Replace the triode oscillator cover by carefully fitting the mating ends of the slotted shaft coupling, then pressing the cover assembly to the triode oscillator plate. Test the

fit by trying to rotate the Mode Cams at the end of the potentiometer shaft. A correct fit will have no play in it at all.

(g) Replace the gray Tracking Potentiometer cover and connector J314.

3. Triode Oscillator Frequency Check. Upon replacement of V301, the alignment of the dial scale should be checked as described in paragraph (a) below. If the dial scale is off frequency by more than $\pm 1\%$ or ± 2 mcs, whichever is greater, the oscillator must be realigned.

(a) Dial Scale Frequency Check. Turn the POWER switch ON and depress RANGE 2/1 button. Set the Indicator controls as follows:

SWEEP RATE 30 cps
VIDEO FILTER OUT
AMPLITUDE SCALE LIN
SWEEP WIDTH RANGE 0 - 5 mc
 (Narrow Band)
IF BANDWIDTH Fully CW
GAIN $1/16$ " of "grass"
MARKER Zero, both ranges
MARKER LEVEL 2 divisions high
CENTER FREQ. Adjust the marker
 pip to center of
 screen.

(1) Feed a 160 mc signal from a calibrated signal generator, such as a Hewlett-Packard Model 608D or equivalent into the DIRECT INPUT jack (10 MC - 11 KMC). Adjust the signal pip amplitude to $1/2$ scale on the CRT. In conjunction with the 5 mc RANGE marker and CENTER FREQ controls, adjust the SWEEP WIDTH control to obtain a 2 mc sweep width (± 1 mc). Return the marker pip to zero. If the marker pip does not coincide exactly with the signal pip, use the 70 mc RANGE marker control to make the marker pip zero beat with the signal. Hereafter, the marker pip will be used to calibrate the frequency dial scale and it SHOULD NOT be moved at any time during the calibration.

(2) Check all numbered points on RANGE #1, starting from 420 mc and moving downward in frequency. Always calibrate a point by moving the dial pointer from right to left (high to low) slowly until the pointer covers the index mark entirely. Estimate the amount of error, if any, by the distance the signal pip is off the marker pip.

If the signal is off to the right of the marker, the dial calibration is low, and the error must be subtracted from the nominal frequency. If the signal is off to the left of the marker, the dial calibration is high, and the error must be added to the nominal frequency.

If the dial pointer is greater in error than ± 2 mc or $\pm 1\%$, whichever is great-

er, the oscillator tracking should be realigned. At the discretion of the user, a calibration chart may be compiled instead of going through the alignment procedure.

4. Dial Pointer Adjustments and Service. It is recommended that, once it is decided to realign the triode oscillator, it is best to start from the beginning. Unless the dial calibration is only slightly off, in the vicinity of an adjustment point, such as; 10 mc, 100 mc, or 260 mc, do not attempt to touch up the calibration.

(a) Dial Pointer Adjustment. On rare occasions the dial pointer may slip on the dial cable, thereby causing the dial calibration to be off. An indication of this trouble is for the percentage of error in calibration to be greater at the high frequency end of the dial than at the low frequency end.

(1) Check the distance of dial pointer travel by measuring the amount of overtravel on each end of the dial scale. The pointer should move no more than $1/8''$ past both ends of RANGE #4/3 dial scale. If the pointer does not travel past either end or if, by judgement, the total distance of overtravel is more than $1/4''$, the points must be reset.

An amount of overtravel greater than $1/4''$, especially if the tuning knob feels spongy, indicates trouble in the drive gear train, usually the gear shaft stops. Unless the user is equipped to handle the repair of the tuning gear train, it is recommended that the entire

Tuning Head be returned to the factory for repair.

(1) To reset the pointer, remove the four spline-socket button-head screws from the dial escutcheon and lift it off the panel. Check that the dial cable is taut and in good condition without broken strands. If the cable is frayed it will be necessary to replace it. (See par. (b) below).

(2) Run the pointer across the dial scale by rotating the TUNING knob. Observe the amount of overtravel. When either end is reached, hold the dial pulley fast with one hand while sliding the pointer to its proper position with the other hand.

CAUTION

Before applying full force to the pointer, carefully test the amount of force needed to move the pointer. If the pointer cannot be moved with a minimum effort, loosen the clip by opening the ears a slight amount. The application of excessive force may cause the dial cable to break.

(3) After relocating the pointer, clamp the ears over the cable to hold it snugly but not tight enough to cut the cable. Apply a drop of cement over the ears.

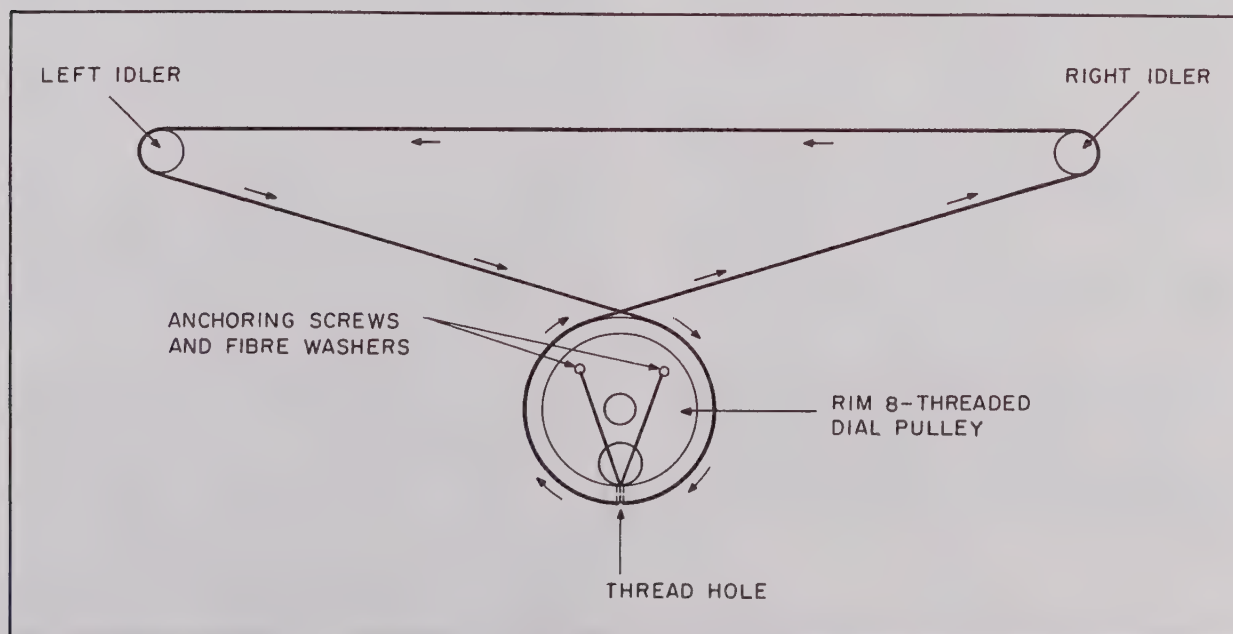


Figure V-23. Dial Cabling Diagram.

(4) Run the pointer back and forth across the dial scale track by rotating the TUNING knob. Observe that it slides smoothly and with a minimum of lateral weaving. If necessary, reform the pointer clip to make it slide smoothly. Wipe the track clean and apply a dab of lubricating grease (Lubriplate) along the track.

(b) Replacement of Dial Cable. In the event that the dial cable has to be replaced, proceed as follows:

(1) Remove the escutcheon as described above (see par. (a) (1).

(2) Loosen the pilot lamp mounting brackets on both sides of the dial scale and move them out of the way.

(3) Remove the mounting screws of the dial scale support from the rear of the panel and lift the support off the panel.

(4) The dial pulley and idlers will now be exposed. Partly loosen the two anchoring screws on the dial pulley and remove any broken or loose ends of the dial cable.

(5) Turn the TUNING knob fully counterclockwise and thread the end of the dial cable through the hole in the pulley rim.

(The replacement dial cable is a length of .012 stranded stainless steel "U control" wire available at any hobby shop).

(6) Use a pair of long-nose pliers to grasp the end of the wire and wind it one and a half times around one of the anchoring screws. Make certain the loop falls under the fibre washer, otherwise the screw head may cut the wire when it is tightened.

(7) Pull the wire taut with the right hand and move the wire clockwise 1/2 turn around the dial pulley, making sure that the wire falls into the same groove as the thread hole.

With the wire still held taut, feed it first around the right idler wheel and then the left idler wheel. Maintain the tension on the dial cable.

(8) Turn the TUNING knob slowly clockwise, while permitting the dial cable to be paid out. When the end of clockwise travel is reached, extend the free end of the cable about six inches to the right of the dial pulley, then bring it down over the thread in which the thread hole is located.

NOTE

Make sure the thread hole is approached in the clockwise direction. If the thread

hole happens to be located in the upper right hand quadrant, 10 - 90° from perpendicular) start one thread further back from the thread hole and wind the cable 1 full turn before reaching the thread hole.

(9) Cut the cable neatly and sufficiently long enough (5") so that it may be fed through the thread hole and wound around the second anchoring screw and fibre washers. Tighten the screw and trim off the cable ends.

(10) Attach the dial pointer to the dial cable. Fit the attachment ears on the clip of the pointer over the cable. Set the pointer onto the slide of the dial support.

(11) Turn the TUNING knob fully clockwise until the end of travel is reached. Slide the pointer until it passes approximately 1/8" to the right of the 2200 mc dial scale mark. Clamp the dial pointer clip just enough to fasten it to the cable. Check the pointer excursion by turning the TUNING knob counterclockwise until the end of travel is reached at the left side of the dial scale. The pointer should stop approximately 1/8" past the 900 mc dial scale mark. If the travel is unequal, slide the pointer to compensate for this. When the pointer excursion is satisfactorily adjusted, apply a drop of cement on the clip ears (refer to par. 4(a) (1), (2), & (3) above).

5. Triode Oscillator Alignment and Calibration. Remove the triode oscillator cover as described in paragraphs 1 or 2 above. Set the adjustments of C309, C310 and C311 so that the slugs just clear the metallic coating on the glass stator of the capacitor. Use the alignment tool (Walsco 2541 or equiv) supplied with the equipment.

Set up the signal generator and marker pip as described in Paragraph 3 above.

(a) Alignment Procedure. Check that the turning track (Ref. 3, Fig. V-2) is clean and free from burrs, especially on the inside contacting surfaces. If necessary, polish the inside surfaces with a piece of crocus cloth or an ink eraser and wash clean with an alcohol-soaked swab.

(1) Loosen the tuning rotor arm by backing off on the setscrew just enough so that the arm may be turned by hand, but is still snug enough so that it will hold its position on the shaft.

(2) Set the dial pointer to the 400 mc mark and the signal generator to give a calibrated 400 mc signal at -65 dbm output. Move the rotor arm slowly until the signal covers the marker pip. This should occur at the 400 mc alignment location on the tuning track. (see Fig. V-22a Ref. 2).

(3) If this is the correct position of the rotor arm, the triode oscillator will be operating at 560 mc (160 mc above dial reading). To check that this is the correct setting, and not a spurious signal, perform the following procedure.

i. Check that the pip varies in amplitude with the generator attenuator control.

ii. Check that the pip moves on the screen. To the left for increasing local oscillator frequency; to the right for increasing signal generator frequency.

iii. Check that the signal level is no greater than -50 dbm for a full scale pip, to ensure a minimum of spurious created by overloading.

(4) Keep the rotor arm far enough away from the base plate so that the contacts do not scratch the base plate material. This is to prevent any erratic movement of the contact points. A good compromise is for the contact points to be visible over the edge of the tuning tracks.

(5) When the 400 mc mark is located, temporarily fit the oscillator cover over the oscillator assembly. Note how far and in what direction the signal pip has shifted from the marker pip. Remove the cover and reset the rotor arm to move the signal the required distance in order to correct for stray capacity. Replace the cover and check the location of the signal. If the signal now coincides with the marker, remove the cover and tighten the rotor arm setscrew. Recheck the location of the signal pip.

NOTE

In serial nos. 151 to 250, the 10 mc trimmer adjustment (C307) may be difficult to reach when the cover is installed. As an aid to the technician, extra holes have been punched in the cover so that light may be directed into the interior and illuminate the area. Serial nos. 251 and up have a slide door for this purpose. If the 10 mc adjustment still cannot be conveniently reached, temporarily remove the cover and allow for shifting signal as described above.

(6) Track the local oscillator and signal generator down in frequency until the 260 mc mark is reached. Adjust the 260 mc

piston trimmer until the signal and marker pips coincide.

(7) Repeat the above step (6) at the 100 mc mark.

(8) Repeat the above step (6) at the 10 mc mark.

(9) Recheck for the 400 mc mark. If the pips do not coincide, repeat step (5).

(10) Recheck all the adjustment points; 260 mc, 100 mc, and 10 mc. If they do not coincide, readjust all the points. It may be necessary to touch up these points several times. This touch up must be done with the cover on.

(11) When all points are adjusted, the cover may be secured. Do not tighten the screws too tight. Use just enough torque to hold the cover snugly. When tightening the cover screws do so at a checkpoint, in order to observe whether or not the signal becomes detuned. If necessary, recheck at all adjustment points and touch up the alignment, where indicated.

(12) After the alignment is completed, check and record all frequencies at all numbered points from 10 mc to 420 mc. They must fall to within $\pm 1\%$ to ± 2 mc, whichever is greater.

f. OPERATIONAL CHECK OF THE KLYSTRON CAVITIES.

The method of checking the operation of either the 6BM6 or 5721 klystron cavities is essentially the same. The differences being in the oscillation frequencies and operating voltages. Before proceeding with the frequency check, perform the resistance and voltage checks given in paragraphs c.6 and d.4. above. Unless these checks show that operating conditions are normal, such as no open or short circuits in the supply and control circuits, do not continue with the alignment procedure for the klystron cavities.

A shorted or open klystron tube circuit may easily be detected by observing the panel meter when it is in the KLYSTRON CURRENT position. The meter should indicate between .4ma and .7ma at the extreme operating ranges. A normal indication is between .5ma and .6ma.

If it is determined that a klystron tube is defective, refer to paragraphs i and j for instructions on removal and replacement of the cavities.

1. Test Set-up for Calibrating and Aligning the Cavities. There are two methods of cali-

brating the klystron tube local oscillators in the Model SPA-4a Spectrum Analyzer. The conventional method, using a calibrated signal generator in the range being aligned, is subject to the hazard of multiplying whatever calibration error there may be inherent in the generator.

A more accurate method is defined in paragraph (a) below. By the use of this method, only the inherent error of the wavemeter need be taken into consideration. The normal calibration error found in wavemeters in general use today, is $\pm .001\%$ of the dial reading. This discrepancy may generally be ignored when performing this alignment.

The Model SPA-4a may have $\pm 1\%$ frequency error throughout the range from 1 KMC to 44 KMC. If the alignment is made carefully, this error may easily be decreased to better than $\pm .05\%$. Although backlash in the tuning mechanism has been kept to a low figure (less than 1%), it is recommended that all alignments and calibrations be made from high to low (right to left) on the dial. This is because the tuning resettability figure of the Model SPA-4a, when approaching from that direction, is practically zero.

2. Klystron Repeller Voltage Modulator. The apparatus needed for this piece of test equipment may be fabricated very easily in any lab. The items and their hook-up are illustrated in Figure V-24.

Figure V-25a shows the Tuning Head adjustments and test points for units with serial numbers 151 through 250. Figure V-25b shows the Tuning Head adjustments and test points for units with serial numbers 251 and up.

3. Interpreting Klystron Mode Signals.

(a) To view the klystron modes of operation, connect the vertical input of a high gain oscilloscope to P335. It is necessary to disconnect P331 from K301 which is located on the center partition of the Tuning Head chassis (Ref. 1, Fig. V-25) and with the use of an adapter, (TNC male at one end) connect P331 to the oscilloscope.

(b) Connect the insulated leads from the isolation transformer to the MOD jacks of the klystron under test (Ref. 3 or 4, Fig. V-25).

(c) Connect the 6 volt sine wave from the test set-up to the horizontal amplifier jacks of the test scope.

(d) Turn all power on and adjust the oscilloscope gain, the Variac and phase controls until a presentation similar to any of the illustrations in Figure V-26 appears.

(e) The presentation of Figure V-26a. illustrates a well-centered mode. The dip in-

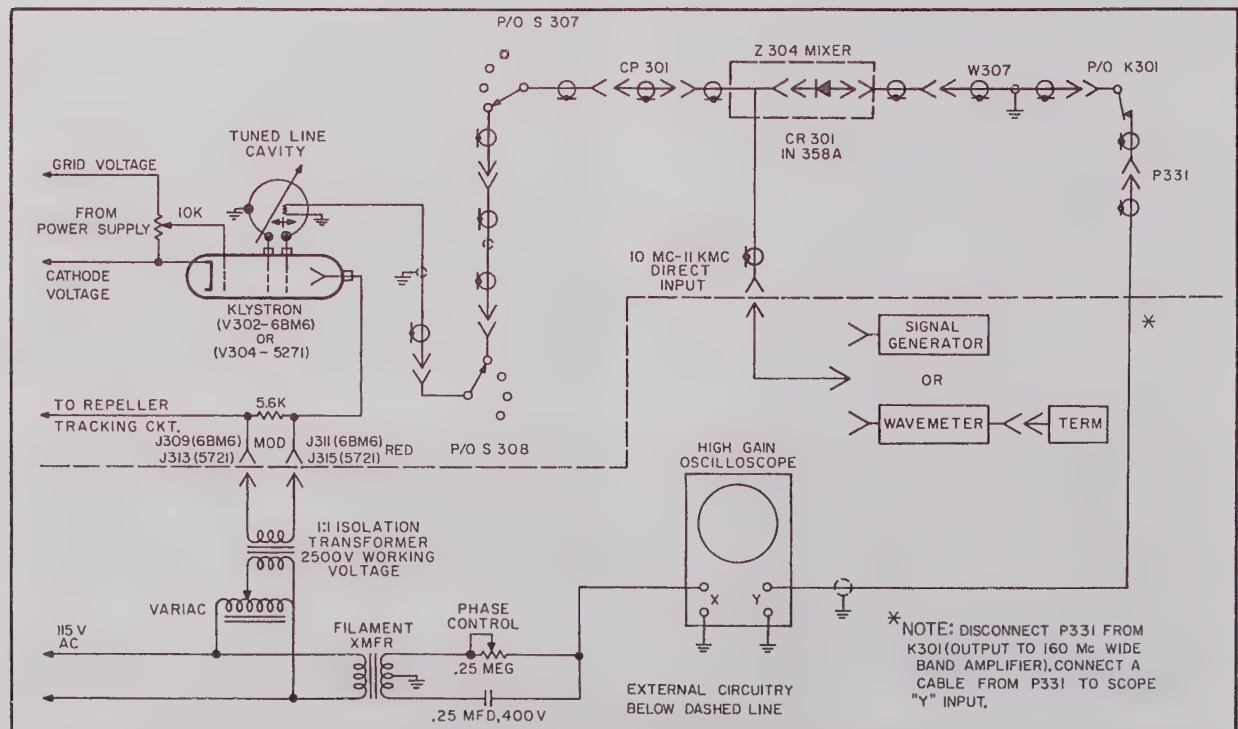


Figure V-24. External Circuitry Hook-Up for Alignment of Tracking Potentiometers and Cams. (Klystron Cavity Alignment)

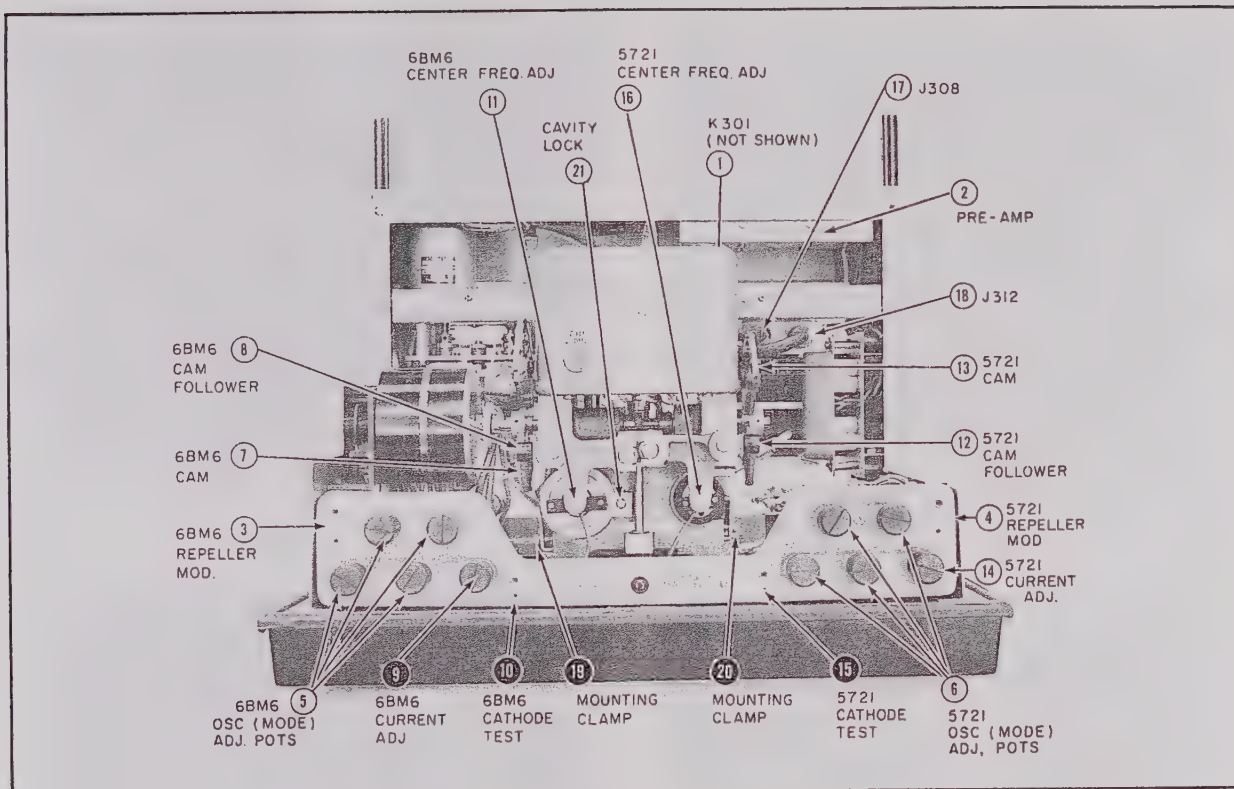


Figure V-25a. Tuning Head (Top View) Ser. Nos. 151-250.

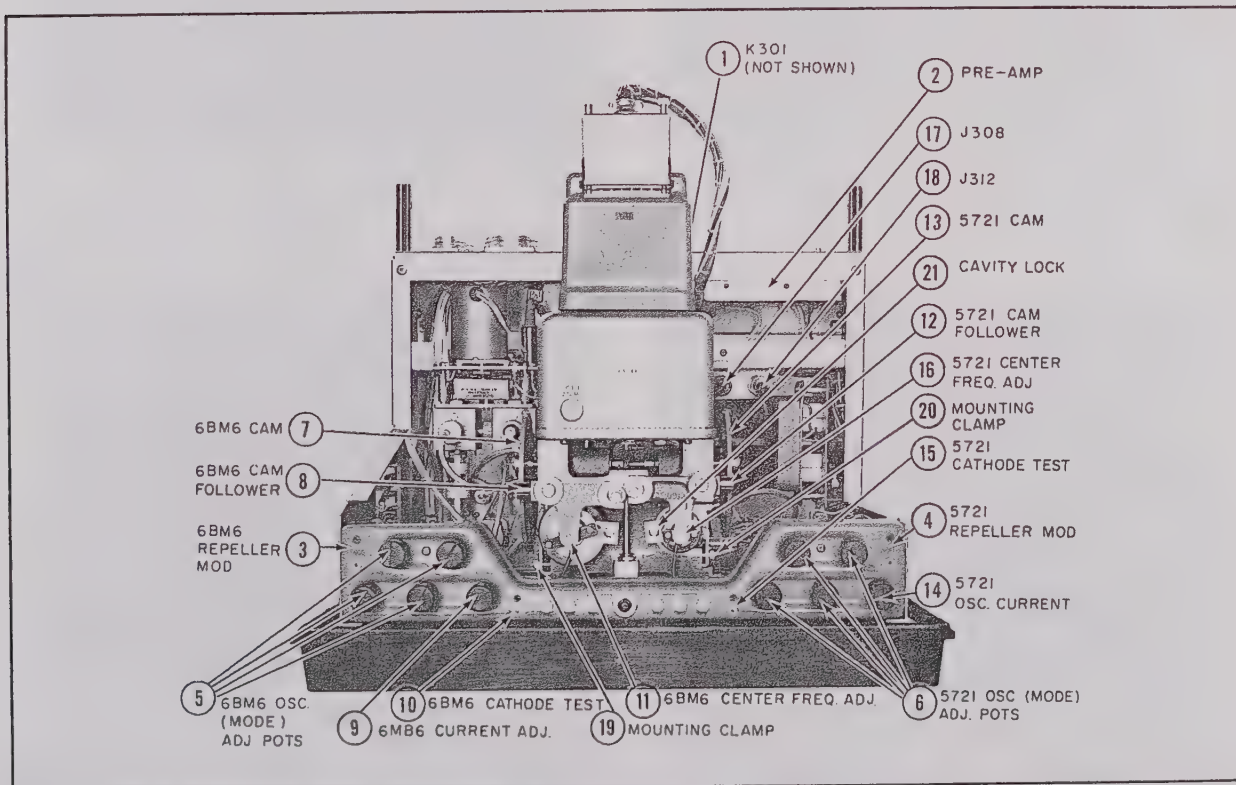


Figure V-25b. Tuning Head (Top View) Ser. Nos. 251-Up.

icates the center oscillation frequency of the mode. For the purposes of calibration, the dip should be located at the peak of the mode. This peak can be accurately determined by reducing the modulation voltage from the Variac until the mode presentation flattens out. When the pip is moved across the mode, the entire mode will deflect on the screen. This indicates dead zero for that calibration point.

(f) Figure V-26b illustrates the presentation when a large modulation voltage is applied. Several modes appear on the screen at once. The purpose of this action is to help locate the desired mode of operation.

(g) Figure V-26c illustrates the presentation when spurious side modes appear to be part of the true mode. They may be differentiated from the true mode by tracking the wavemeter pip through the modes. The pip will disappear at the extremities of the true mode and will not follow through to the spurious modes.

The spurious modes may be several hundred megacycles away from the true mode, so that in operation they will not be objectionable because of the i-f rejection factor. Therefore, no spurious signals will appear near the true signals because of the spurious klystron modes.

(h) Figure V-26d illustrates the presentation when the output of a signal generator is mixed with the klystron output. It is used and manipulated in the same manner as a wavemeter dip as explained in paragraph (d) above.

(i) Figure V-26e illustrates the presentation of an uncentered klystron mode. Adjustment of the OSC ADJ potentiometers for the klystron under observation should be made to center the mode (Ref. 5 or 6, Fig. V-25).

(j) Figure V-26f illustrates another presentation of spurious klystron modes. The explanation in paragraph (g) above is also applicable for this condition.

(k) The presentation shown in Fig. V-26 illustrate so-called "normal" appearing modes and use the ideal presentation of such. They may sometimes appear much smaller in amplitude because of a poor match somewhere in the transmission chain. If the mismatch is very bad, the detected output may disappear entirely. A good rule of thumb in order to determine a usable klystron power output, is to consider any detected output over 1 millivolt in the test scope as passable. Any detected voltage less than 1 millivolt will not supply enough conversion power to provide sufficient r-f signal sensitivity for normal operation.

(1) The repeller mode will appear similar to that shown in Figure V-27 when an open circuit exists in the test set up shown in Figure V-24. The usual causes of this trouble are: broken resistors in the cavity probes, open grounds anywhere in the circuit, poor contact in any of the switches.

g. ALIGNMENT AND CALIBRATION OF THE CAMS AND TRACKING POTENTIOMETERS (6BM6).

The alignment of the 6BM6 klystron cavity requires the set-up and the use of the information given in paragraph f. above. The instructions contained in this paragraph may be followed when performing a complete alignment or when touching up the calibration of a slightly misaligned cam.

1. Centering the Mode. After setting up the test circuit, connect the repeller modulator leads to the 6BM6 MOD jacks J309 and J311 (Ref. 3, Fig. V-25).

(a) Set the METER FUNCTION switch to the KLYSTRON CURRENT position.

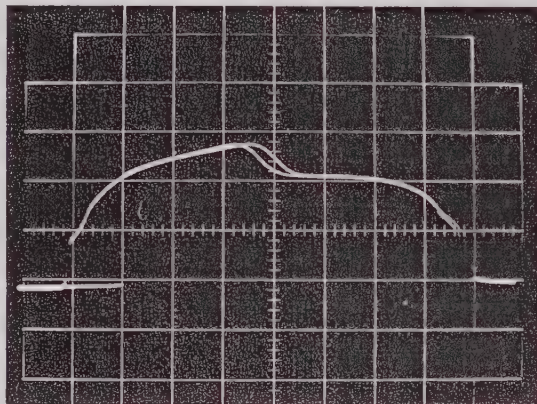
(b) Turn the main TUNING knob counterclockwise until the dial pointer indicates 1540 MCS on the #4/3 RANGE. At this point on the dial, the cam follower (ref. 8, Fig. V-25) should rest slightly to the low frequency side of the dead spot (Ref 7, Fig. V-28). It is usually not necessary to readjust for this setting unless, through long use and vibration, the cam has slipped on its shaft. In that event, loosen the setscrews on the cam hub and carefully reset the cam.

(c) Set the 6BM6 CURRENT ADJ control (Ref 9, Fig. V-25) fully counterclockwise. Press the RANGE #4/3 button. After 5 seconds the klystron power should turn on and the KLYSTRON CURRENT panel meter should read between 4.5 and .7ma.

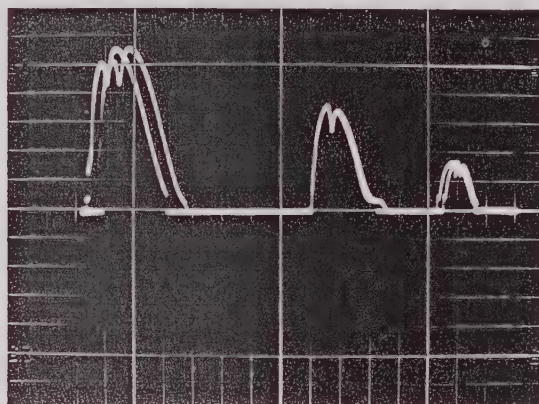
(d) Adjust the wavemeter or signal generator to 1700 MCS (L.O. +160 MCS). A scope presentation similar to Fig. V-26a or d should appear. If the cavity is far out of alignment, it may be necessary to increase the modulation voltage so that two or three repeller modes appear as in Fig. V-26b.

(e) Find the oscillation frequency by searching with the wavemeter or signal generator until the signal pip appears on the mode.

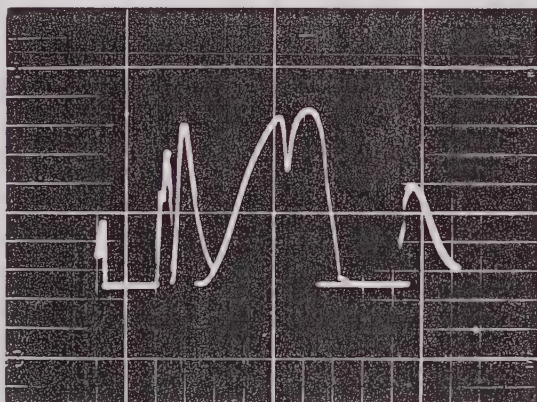
(f) To determine which is the correct mode of operation, refer to Fig. V-29. The 1-3/4 mode is used from 900 to 1600 MCS. and the 2-3/4 mode is used from 1600 to 2350 MCS



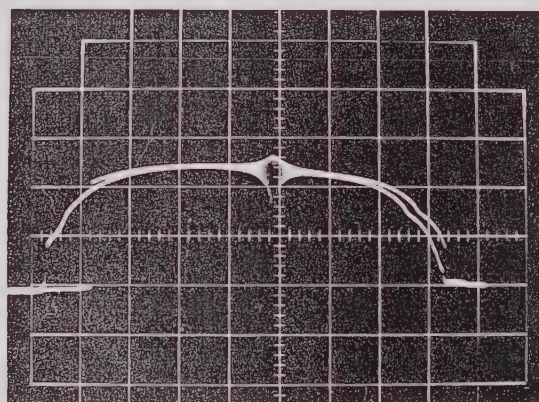
a. Klystron repeller mode with wavemeter dip.



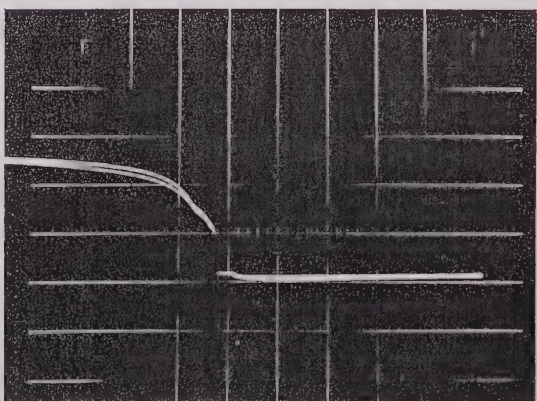
b. Three klystron repeller modes on a single sweep.



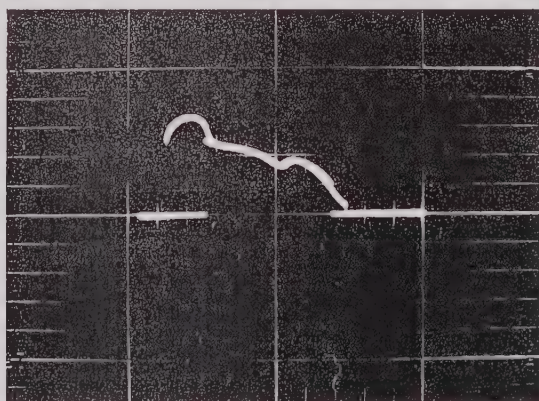
c. Klystron repeller mode with spurious modes at low end of band of 5721 oscillator.



d. Klystron repeller mode with signal generator marker pip.



e. Uncentered klystron repeller mode.



f. Klystron repeller mode with spurious mode at low end of band of 6BM6 oscillator.

Figure V-26. Various Repeller Mode Oscilloscope Presentations.

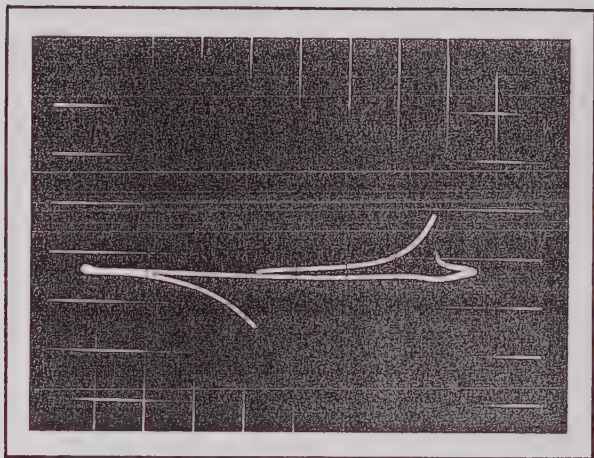


Figure V-27. Appearance of Repeller Mode Due to an Open Circuit.

on the 6BM6 cavity. The information given in paragraph d.4. describes the adjustment of the repeller tracking potentiometers. In order to set the mode of operation perform the following adjustments:

(1) Connect a voltmeter between the two white test jacks (Ref. 3 and 10, Fig. V-25). By referring to Fig. V-29 it can be seen that the mode of operation for 1700 MCS is the 2-3/4 mode and that the voltage should be approximately -120 volts across cathode and repeller.

(2) If the signal pip does not fall on the peak of the mode on the test scope, adjust the center frequency adjustment screw (Ref. 11, Fig. V-25) until the pip is centered on the modes. (Fig. V-26b).

(3) To select the 2-3/4 mode; reduce the modulation voltage with the variac and then adjust the 1.45 KMC OSC ADJ potentiometer (Ref. 5, Fig. V-25) until the mode centers on the test scope screen. (Fig. V-26a or d).

The dial and cam are now centered. The alignment and calibration procedure is described below.

2. Aligning the Cavity. Normally, once the cam and mode are centered, the alignment should fall in automatically because the cam adjustments made at the factory should not have changed much since then. However, when installing a new klystron tube, a new alignment might become necessary because of the tube characteristics or variations in other adjustments. Proceed with the alignment as follows; always making adjustments from high to low.

(a) Turn the tuning knob counter-clockwise from the 1540 mc point until the mode

switch is heard to click. This should happen between 1400 and 1450 MCS. Tune to 1400 MCS and note how the mode is centered on the oscilloscope screen. If it requires centering, adjust the 1.43 KMC OSC ADJ potentiometer.

(b) Tune to 1000 MCS on the dial. Check the alignment with the wavemeter or signal generator tuned to 1160 MCS. If necessary, adjust the #5 cam adjustment nut until the signal centers on the mode. Center the mode on the scope screen with the .9 KMC OSC ADJ potentiometer.

(c) Check the alignment at the #3 and #4 cam adjustment points in the same manner with the signal pips. DO NOT make any further adjustments on the OSC ADJ potentiometer except when recrossing over the mode switching point for the first time. It may be necessary to touch up the 1.43 KMC potentiometer for the 1-3/4 mode and the 1.45 KMC potentiometer for the 2-3/4 mode.

(d) Check the alignments at #2 and #1 cam adjustment points in that order and center the signal pip on the mode if necessary.

NOTE

Make all cam alignments when moving away from center. Try to keep the tracking edge curve as constant as possible. Avoid straining the yoke screws. If the alignment is acceptable, the spacing between the tracking edge and cam proper will be practically parallel. It

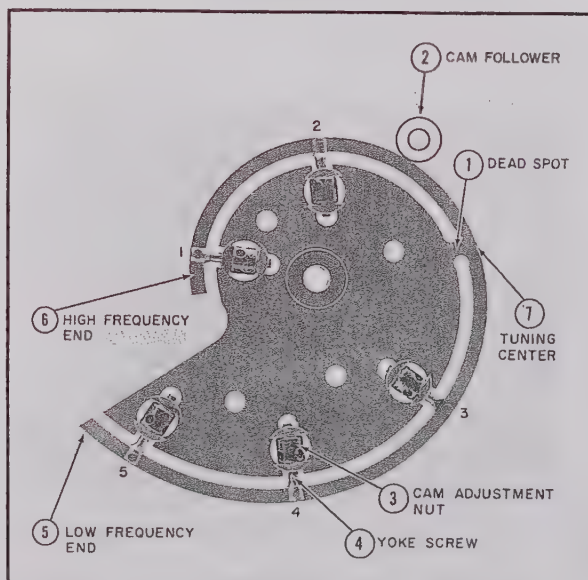


Figure V-28. Frequency Cam Assembly.

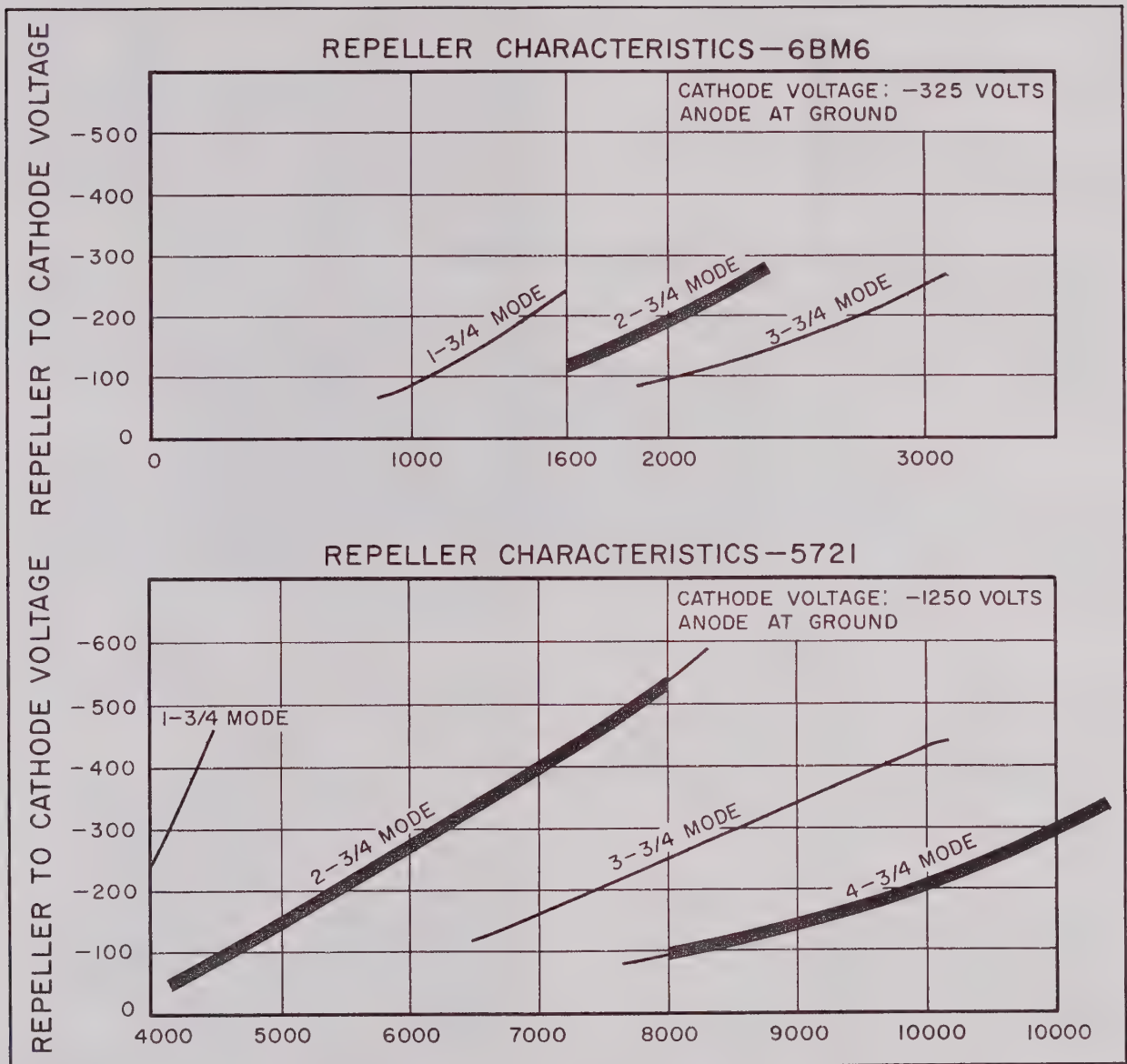


Figure V-29. Repeller Characteristics, 6BM6 and 5721.

may be necessary to recheck and touch up all points before the alignment can be considered to be completed.

3. Calibrating the Cavity. After the alignment is satisfactorily completed, the dial calibration may be taken. As previously stated, all calibrations are taken from the high end of the dial and moving down to the low frequency end. If the pointer inadvertently passes through the dial scale mark, do not return from left to right but do shift to a high position and then carefully tune to the required point from right to left.

The calibration frequencies are determined in the same manner as during the

alignment, but this time a reading is taken for every numbered point, or at the points of interest to the operator. No adjustments are made during calibration.

h. ALIGNMENT AND CALIBRATION OF THE CAMS AND TRACKING POTENTIOMETERS (5721).

The alignment and calibration of the 5721 klystron cavity is performed in the same manner as described for the 6BM6 cavity. The pertinent test points, adjustments and operating frequencies are described in this paragraph. Connect the test set-up shown in Fig. V-24.

1. Centering the Mode.

(a) Set the METER FUNCTION switch to KLYSTRON CURRENT position.

(b) Connect the repeller modulator leads to the 5721 MOD jacks, J313 and J315 (Ref. 4, Fig. V-25).

(c) Turn the main TUNING knob counterclockwise until dial pointer indicates 7850 mc on the #5 RANGE. At this point the cam follower (Ref. 12, Fig. V-25) should rest slightly to the high frequency side of the dead spot. (Ref. 7, Fig. V-25). It is usually not necessary to re-adjust for this setting, unless the cam has slipped on its shaft.

(d) Turn POWER on and push the #5 RANGE button. After approximately 1 minute and 5 seconds the klystron current reading will appear on the panel meter. It should read between .5 and .6 on the meter scale. If this reading does not appear, set the 5721 CURRENT ADJ control (Ref. 14, Fig. V-25) for .55.

(e) Adjust the wavemeter or signal generator to 8010 mc (L.O. + 160 mc). Proceed as described in paragraph g.1.(d), (e), and (f) above. However, now the modes of operation are the 2-3/4 and 4-3/4 modes of the 5721 klystron. By referring to Fig. V-29, it can be determined that the 1-3/4 mode is used from 4560 mc to approximately 7450 mc and the 4-3/4 mode is used from 7950 mc to 11.01 kmc.

(f) Connect a voltmeter between the two white test jacks (Ref. 4 and 15, Fig. V-25). Fig. V-29 illustrates that 7850 mcs on the dial (8010 mcs on the wavemeter or signal generator) is on the low end of the 4-3/4 mode and that repeller voltage across the test jacks should be approximately -100 volts.

(g) If the signal pip does not fall on the peak of the mode on the test scope, adjust the center frequency adjustment screw (Ref. 16, Fig. V-25) until the pip centers on the mode (Fig. V-26b).

(h) To select the 4-3/4 mode, reduce the modulation voltage with the Variac and then adjust the 7.85 KMC OSC ADJ potentiometer (Ref. 6, Fig. V-25) until the mode centers on the screen. (Fig. V-26a or d).

The dial and cam are now centered. The alignment and calibration procedure is described below.

2. Aligning the Cavity. As stated in paragraph h.2., once the dial and cam are centered the alignment should fall in automatically.

However, should an alignment be found to be necessary, proceed as follows:

(a) Turn the dial knob counterclockwise from 7850 MCS point until the mode switch is heard to click. This should occur between 7850 and 7800 MCS. Tune to 7800 MCS and note how the mode is centered on the scope screen. If it requires centering, adjust the 7.83 KMC OSC ADJ potentiometer.

(b) Tune to 4500 MCS on the dial. Check the alignment with the wavemeter or signal generator tuned to 4660 MCS. If necessary adjust the #5 cam adjustment nut until the signal centers on the mode. Center the mode on the scope screen with the 4.4 KMC OSC ADJ potentiometer.

(c) Check the alignment at the #3 and #4 cam adjustments in the same manner with the signal pips. Do not make any further adjustments on the OSC ADJ potentiometers except when recrossing over the mode switching points for the first time. It may be necessary to touch up the 7.83 KMC potentiometer for the 2-3/4 mode and the 7.85 KMC potentiometer for the 4-3/4 mode.

(d) Check the alignments at #2 and #1 cam adjustment points in that order and center the signal pip on the mode if necessary.

NOTE

Make all cam adjustments when moving away from center. Try to keep the tracking edge curve as constant as possible. Avoid straining the yoke screws. If the alignment is good, the spacing between the tracking edge and cam proper will be practically parallel. It may be necessary to recheck and touch up all points before the alignment can be considered completed.

3. Calibrating the Cavity. The dial calibration is performed in the same manner as for the 6BM6 cavity. When the alignment is completed, start from the high frequency end and track on down to the low frequency end. Take the calibration readings at every numbered point; or at the points of interest to the operator.

If the pointer inadvertently passes through the dial scale mark, do not return from left to right but do shift to a higher position and then carefully tune to the required point from right to left. No adjustments are made during calibration.

i. REMOVAL AND REPAIR OF 6BM6 KLYSTRON CAVITY ASSEMBLY.

If it has been determined that the 6BM6 klystron tube needs replacement, or that the cavity

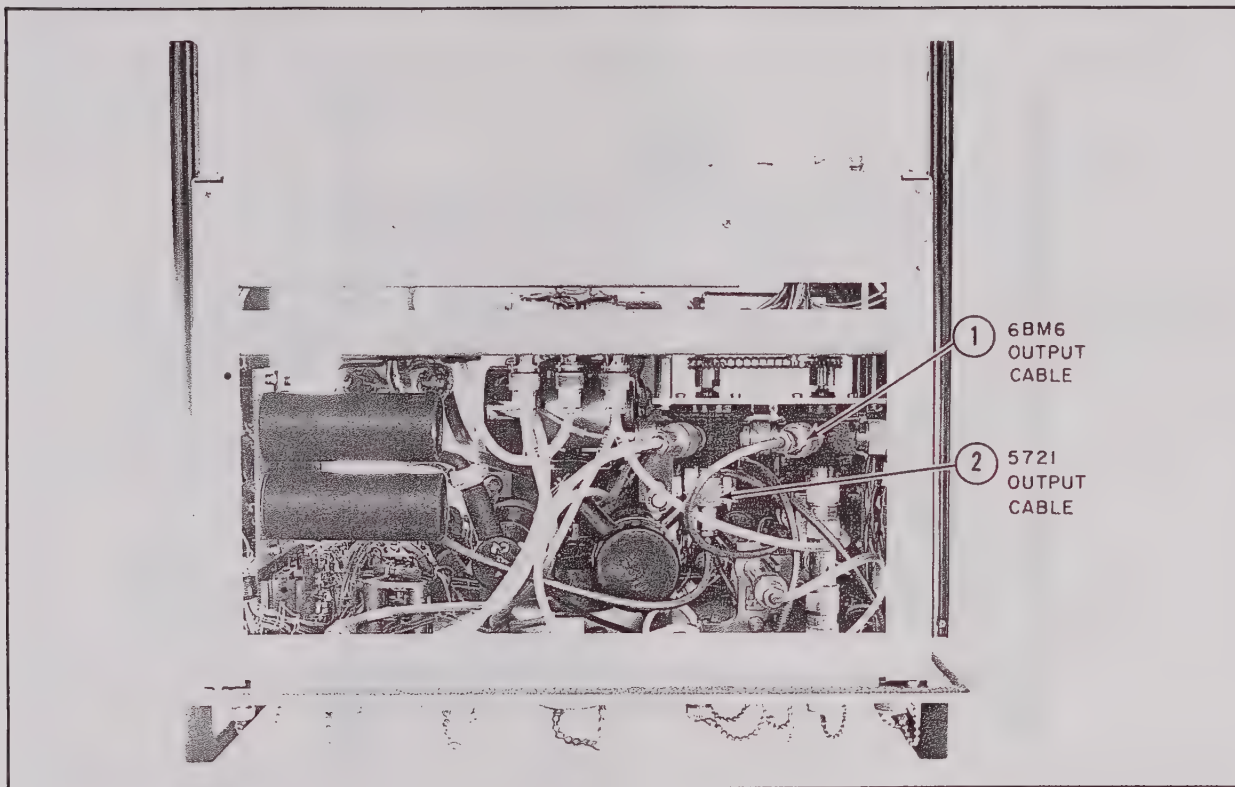


Figure V-30a. Tuning Head (Bottom View) Ser. Nos. 151-200.

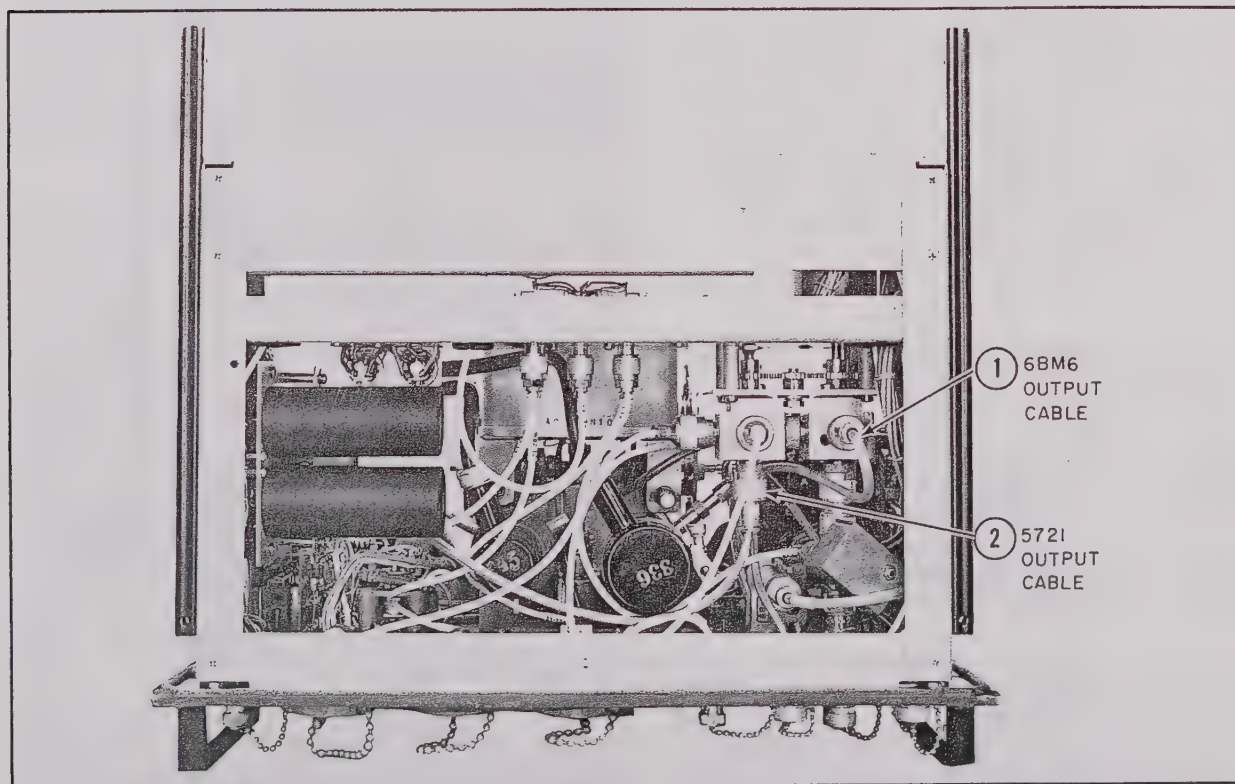


Figure V-30b. Tuning Head (Bottom View) Ser. Nos. 201-250.

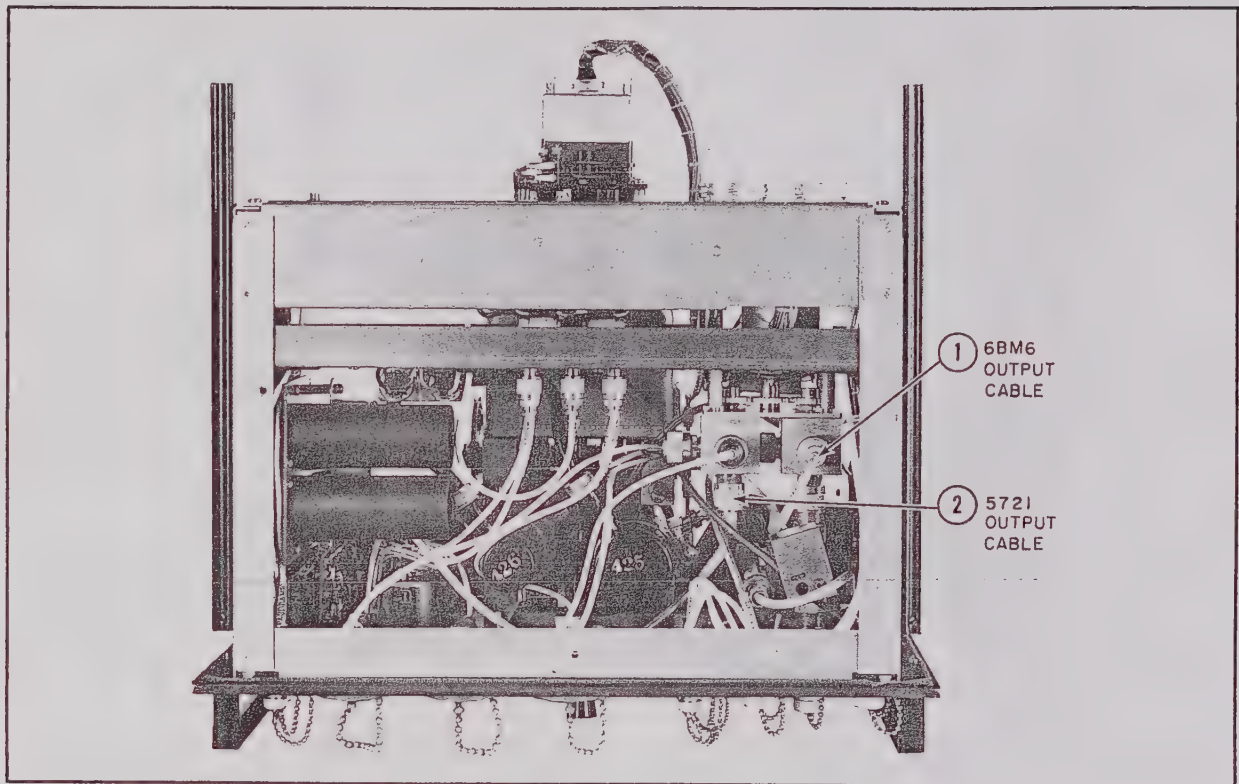


Figure V-30c. Tuning Head (Bottom View) Ser. Nos. 251 and up.

needs repair, it is best to remove the entire cavity from the Tuning Head. It is difficult for a field technician to remove or install the 6BM6 tube in a mounted cavity without the risk of breakage. It is advisable at this time to remove all parts of the klystron cavity so that they may be inspected for wear and dirt. Dirt specks are the most common cause of trouble. They may cause r-f shorts or arcing.

1. Removing the 6BM6 Cavity Assembly.

(a) Disconnect the 6BM6 power plug P308 from J308 (Ref. 17, Fig. V-25) and the 6BM6 output plug (Ref. 1., Fig. V-30a and b).

(b) Unsolder the repeller voltage lead from the red MOD jack (Ref 3, Fig. V-25).

(c) Remove the Center Frequency Adjustment screw and tension spring (Ref. 11, Fig. V-25) from the yoke and crossbar.

(d) It is necessary to remove the tracking potentiometer (for serial nos. 151 to 250 only) and the frequency cam assembly (Ref. 7, Fig. V-25) before the 6BM6 cavity can be removed for repair. Refer to paragraph V-4.c.6.(d) for instructions regarding this step.

(e) After the tracking potentiometer and frequency cam have been removed, remove the cavity mounting clamp (Ref. 19, Fig. V-25). Slide the 6BM6 cavity assembly out of the gear casting. (Some units have an additional lock which also must be removed).

(f) It is helpful to unfasten the potentiometer mounting board and to move it out of the way when working on the klystron cavities.

2. Replacing the 6BM6 Klystron Tube.

(a) Remove the cavity assembly from the Tuning Head. Sight in line with one of the push rods of the center conductor assembly and mark a line with a pencil on the side of the barrel to show the positioning of the choke when reassembling the cavity.

(b) Remove the end bell clamp (Ref. 13, Fig. V-31) and remove the end bell assembly (Ref. 1, Fig. V-31).

(c) Unscrew and remove the tube retaining lock nut (Ref. 2, Fig. V-31a).

(d) Remove the tube retainer with spring contact (Ref. 3, Fig. V-31a). It may be necessary to use a twisting motion to remove retainer from the barrel assembly.

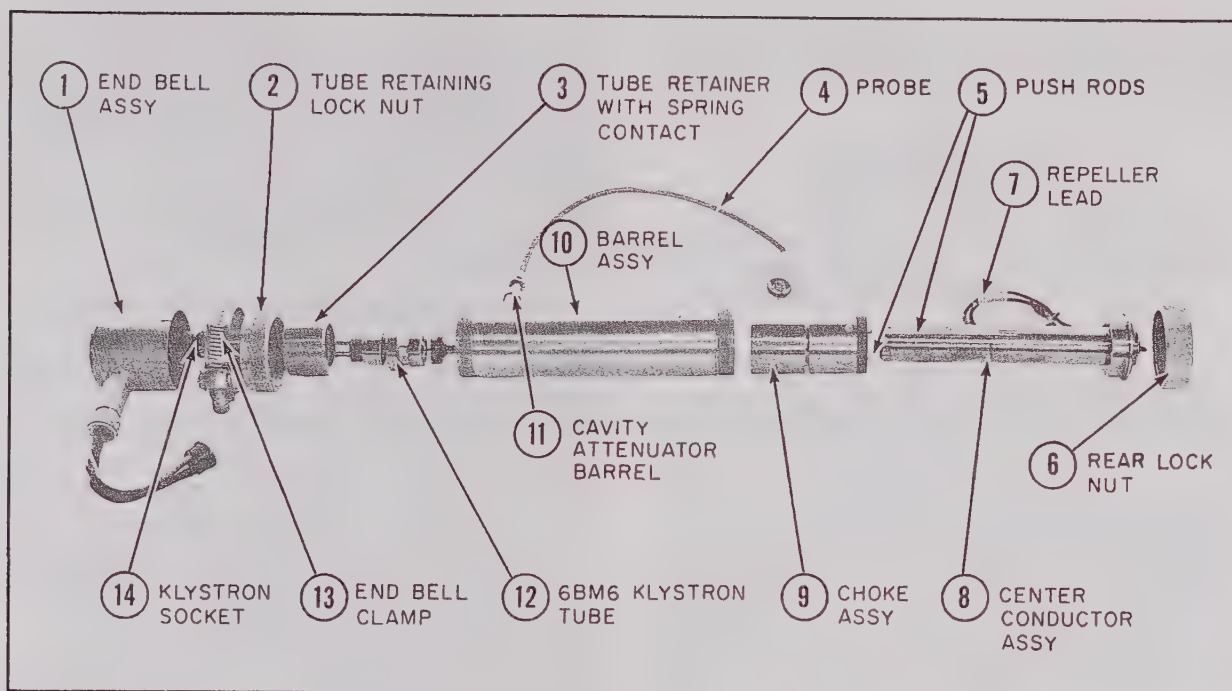


Figure V-31a. 6BM6 Klystron, Exploded View.

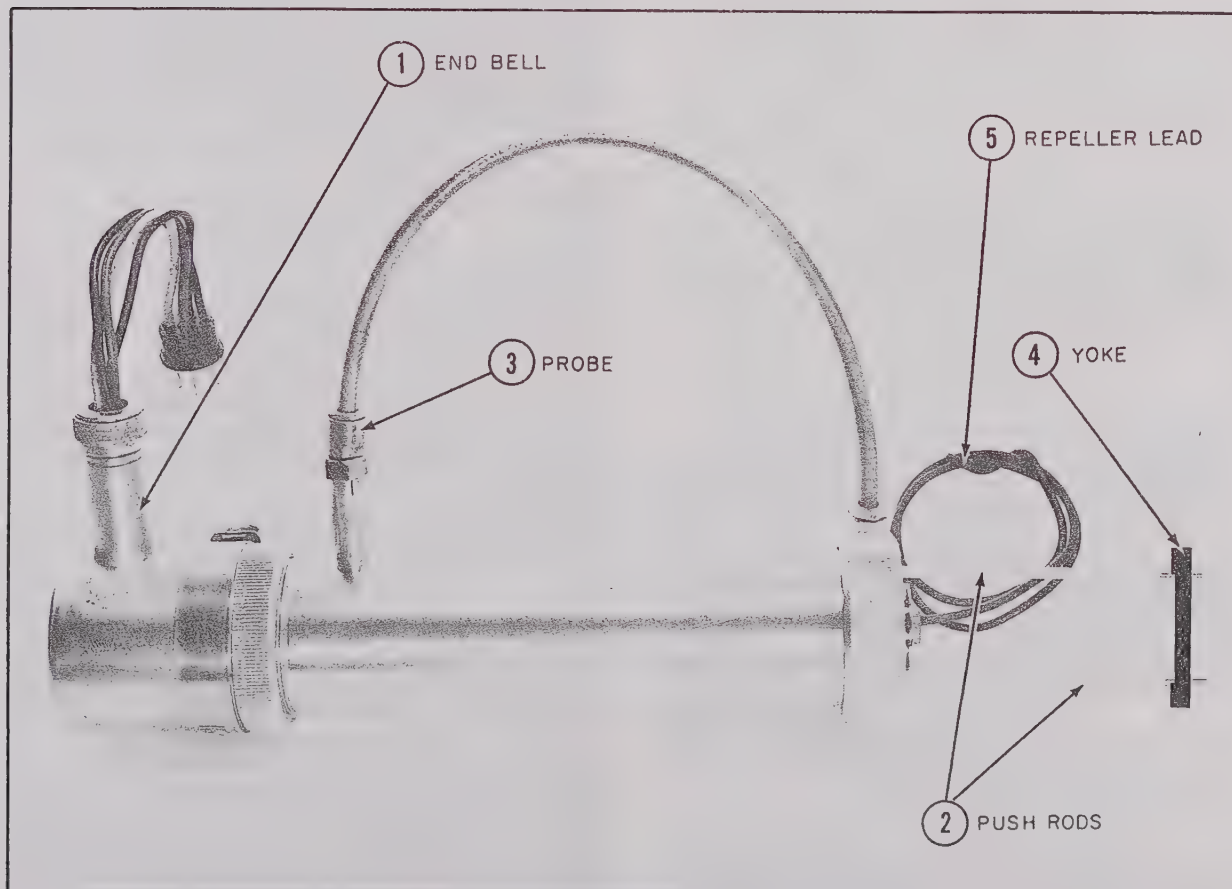


Figure V-31b. 6BM6 Klystron Cavity Assembly.

(e) Remove the 6BM6 klystron tube (Ref. 12, Fig. V-31a) from the spring fingers of the center conductor assembly with a twisting motion. (Ref. 8, Fig. V-31a).

WARNING

Take special precaution to twist only with a radial motion and to pull tube outward at the same time with a steady motion. Any slip of the hand may cause the tube to break.

(f) Unscrew the rear lock-nut (Ref. 6, Fig. V-31) and pull out the center conductor and choke assemblies (Ref. 8 and 9, Fig. V-31a)

(g) The barrel assembly (Ref. 10, Fig. V-31a) is now free and clear. Hold the barrel to a light and sight through it and inspect closely for dust specks. Use a magnifying glass for this purpose. Clean the inside of the barrel with a lint-free cloth or tissue paper dampened with an approved solvent. Reinspect for dust or lint particles. Make sure the barrel is absolutely clean before reassembly.

(h) Inspect the choke assembly for wear and for cracks in the ferrite absorber ring. A cracked ring should be replaced. Check the condition of the teflon guide buttons and or the teflon inner liner (some units do not have the inner liner).

(i) Inspect the condition of the inner conductor assembly. It should be smooth and clean. Using a very light pressure, roll the fingered end of the center conductor between the palm of one hand and a table top to compress and equalize the tension of the fingers.

CAUTION

Do not use too much pressure. It is sufficient to straighten the alignment of the fingers so that they will grip evenly about the grid of the klystron tube.

(j) Reassemble the choke and center conductor. Align the push rods with the mark on the outer barrel made in step (a) above and insert the center conductor into the barrel. Fasten the center conductor in place with the rear lock nut.

(k) Insert the replacement 6BM6 tube (if required) into the open end of the center conductor as far as it will go. The fingers should cover most of grid #2 of the tube.

(l) Install the tube retainer with the coiled spring end facing the tube. Use a twisting motion and push it on until it clicks into place.

(m) Inspect the Metex inner gasket of the tube retaining lock nut to see that it is not too compressed and flattened. To rejuvenate the gasket, remove it from the nut and flex it a bit. Replace it into its groove and install the nut on the barrel. Tighten the nut as much as possible with hand pressure. Test the grip of the lock nut by trying to remove the tube retainer through the lock nut. If it remains tight to the hand, it will be satisfactory.

(n) Replace the end bell assembly by first attaching the tube plug to the tube pins and then resetting the end bell in the same position it was previously (par. (a)). Install and tighten the end bell clamp as much as possible.

NOTE

If at any time during the above procedure, the condition of the parts are found to be unsatisfactory, they should be repaired. If facilities are not available for this, the unit should be returned to the factory for complete repair.

3. Replacing the 6BM6 Cavity Assembly.

(a) Replace the cavity in the same position and orientation as before it was removed, otherwise it will be found that the tracking movement will be hampered. The rear lock nut should butt up against the casting.

(b) Install the cavity mounting clamp. (ref. 19, Fig. V-25a).

(c) Replace the cavity lock (ref. 21, Fig. V-25a).

(d) Replace the klystron socket into J308. Solder the repeller lead to the red MOD jack.

(e) Note the three horizontal marks on the glass push rods. These marks indicate the two end limits and the center frequency point of travel.

(f) Set the main TUNING dial to read 1540 on the 1-4.5 mc range.

(g) Install the center frequency adjustment screw with the tension spring between the yoke and crossbar. The tension spring should have its wider end resting on the yoke.

(h) Turn the adjustment screw so that the center marks on the glass rods just emerge from the holes in the cavity. A proper adjustment will make the yoke fit with just enough play so that it will move freely when jiggled against the crossbar without a feeling of looseness.

(i) If the center marks cannot be aligned properly with the adjustment screw alone, it will be necessary to loosen the setscrews on the yoke and to adjust the height of the glass rods by combining the two methods.

CAUTION

Always retain a grip on the push rods. If the choke assembly falls into the cavity the choke may break the klystron tube.

(j) Replace the frequency cam and repeller tracking potentiometer as explained in paragraph V-4.c.6.(d). Align the cavity using the procedure given in paragraph V-4.g.

j. REMOVAL AND REPAIR OF THE 5721 KLYSTRON CAVITY ASSEMBLY.

If it has been determined that the 5721 klystron tube needs replacement, or that the cavity needs repair, it is best to remove the entire cavity from the Tuning Head. It is difficult for the field technician to remove or install the 5721 tube in a mounted cavity without the risk of breakage. It is advisable at this time to remove all parts of the klystron cavity so that they may be inspected for wear and dirt. Dirt specks are the most common cause of trouble. They may cause r-f shorts or arcing.

1. Removing the 5721 Cavity Assembly.

(a) Disconnect the 5721 power plug P312 from J312 (Ref. 18, Fig. V-25) and the 5721 output plug (Ref. 2, Fig. V-30a and b).

(b) Unsolder the repeller voltage lead from the red MOD jack (Ref. 4, Fig. V-25).

(c) Remove the cavity lock (ref. 21, Fig. V-25b, for Ser. nos. 251-up only.)

(d) Remove the center frequency adjustment screw and tension spring (Ref. 16, Fig. V-25) from the yoke and crossbar.

(e) The 5721 cavity assembly may be removed from the casting without removing the frequency cam (Ref. 13, Fig. V-25) if the cam is tuned to approximately 4600 mc on the dial scale.

Remove the cavity mounting clamp (Ref. 20, Fig. V-25) and gently work the cavity assembly out. Do not force the cavity through any apparent opening because serious damage may be done to a projecting part. For example, a nick impressed on the tracking edge of the frequency cam may cause an undesirable skip in tracking during normal operation.

(f) It is helpful to unfasten the Potentiometer mounting board and move it out of the way when performing the service in this paragraph.

2. Replacing the 5721 Klystron Tube.

(a) Remove the cavity assembly from the Tuning Head. Sight in line with one of the push rods and mark a line on the side of the barrel to show the positioning of the choke required when reassembling the cavity.

(b) On the cavity assemblies provided with magnetic shields (See Fig. V-32b), remove the shield by twisting the lower half free from the locking slot and then sliding both halves off the cavity.

Remove the end bell assembly (Ref. 1, Fig. V-32) by gently pulling it off the tube retaining lock nut (Ref. 2, Fig. V-32 a & b). Disconnect the power socket from the base of the klystron tube. On assemblies without the magnetic shield, remove the end bell clamp (Ref. 15, Fig. V-32 and then disengage the end bell assembly.

(c) Unscrew and remove the tube retaining lock nut (Ref. 2, j-32 a & b).

(d) Remove the 5721 klystron tube (Ref. 14, Fig. V-32a) with a twisting motion from the spring fingers of the center conductor assembly (Ref. 10, Fig. V-32 a & b).

WARNING

Take special precautions to twist with only a radial motion and to pull the tube steadily outward at the same time. Any slip of the hand may cause the tube to break.

(e) Normally, the tube retaining wedge and contact rings (Ref. 3, 4, and 5, Fig. V-32 a & b) will come out with the same operation, because the retaining ring will be jammed into the wedge. It will be necessary to release the retaining ring from the wedge and tube before it can be removed. This can be done by inserting the blade of a screwdriver at the seam, between the retaining ring and wedge ring, and gently tapping the rings free from the tube.

CAUTION

This must be done very carefully to avoid breaking the tube. A service hint here is to grip the entire piece solidly in one hand while tapping the positioned screwdriver.

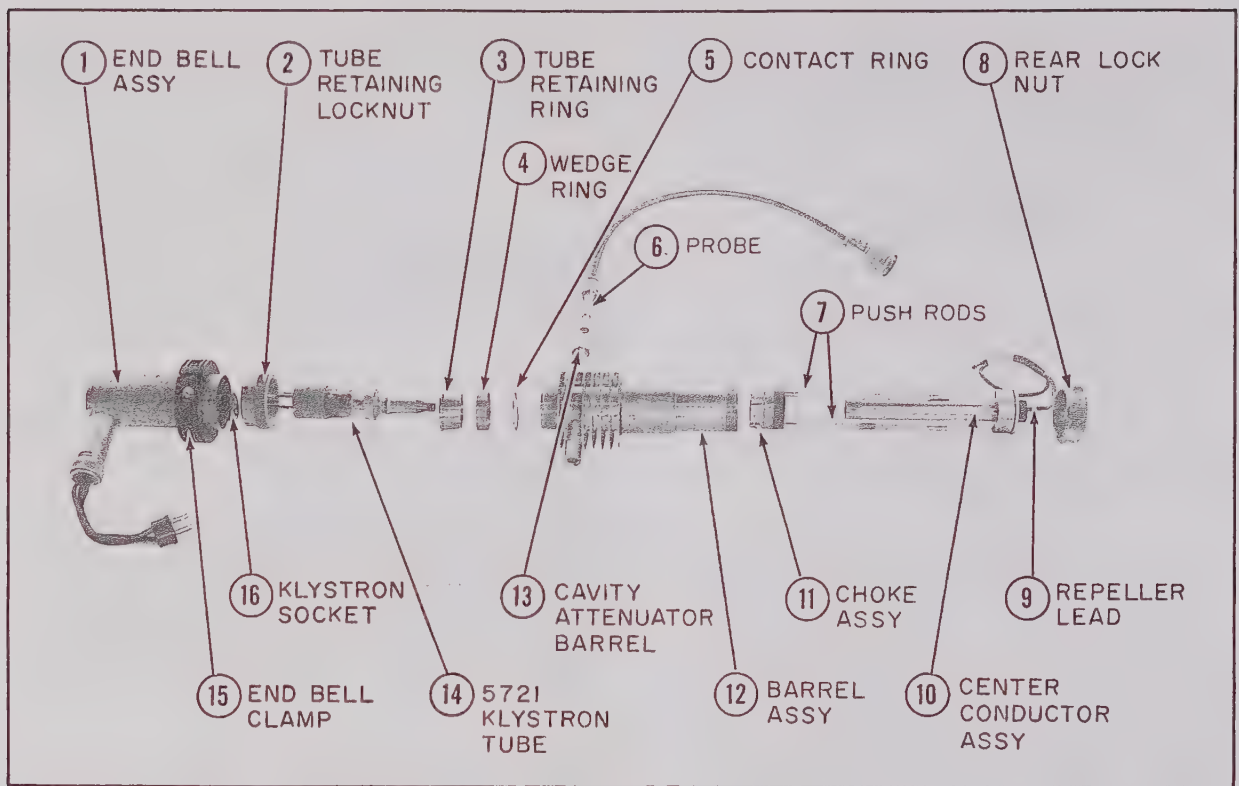


Figure V-32a. 5721 Klystron Cavity (Exploded View) Ser. Nos. 151-250.

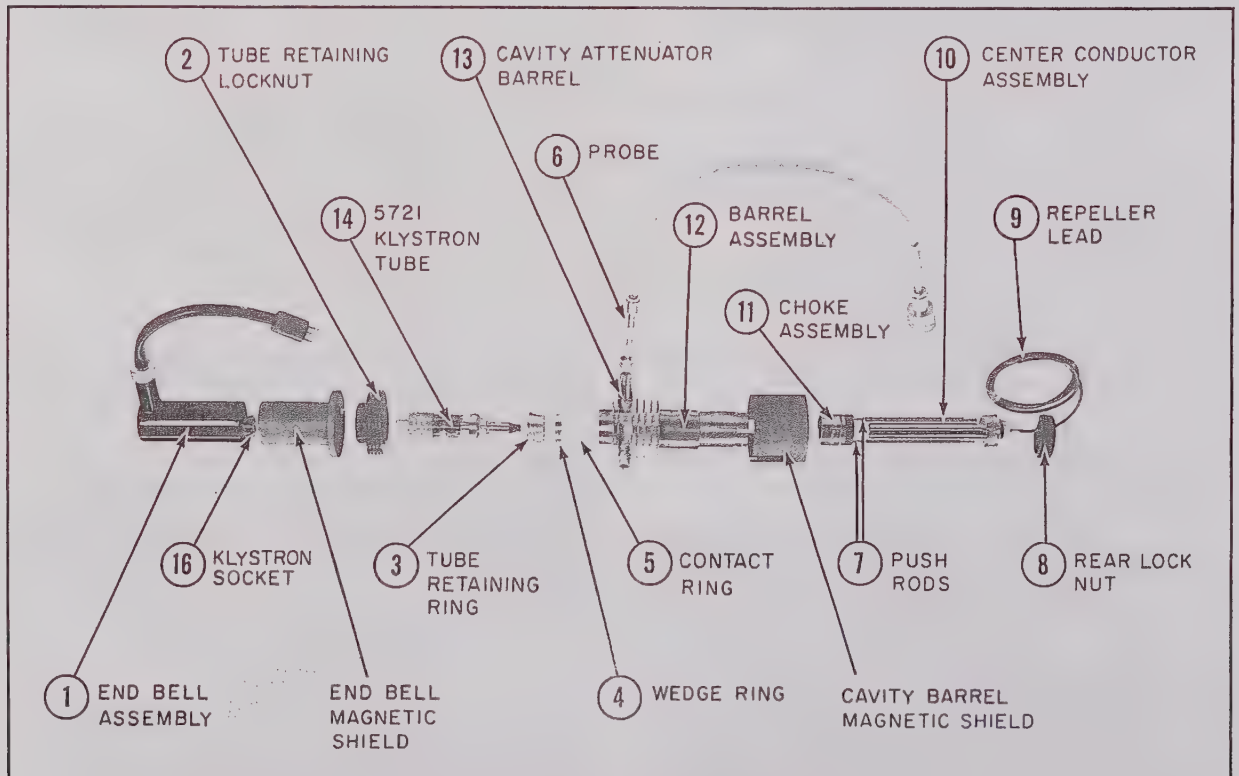


Figure V-32b. 5721 Klystron Cavity (Exploded View) Ser. Nos. 251-Up.

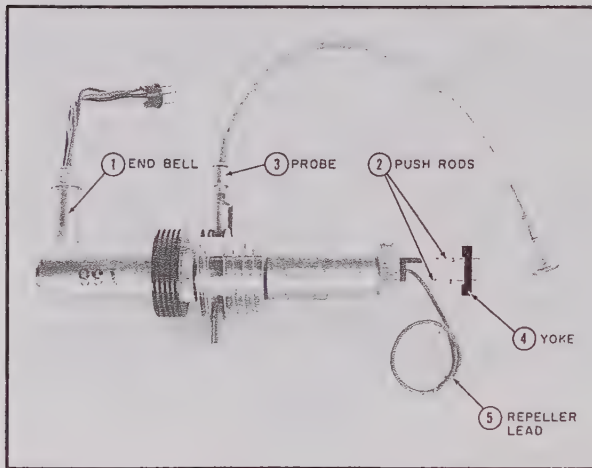


Figure V-33. 5721 Klystron Cavity Assembly.

(f) Unscrew the rear lock-nut (Ref. 8, Fig. V-32 a & b) and pull the center conductor and choke assemblies out of the barrel assembly (Ref. 10, 11, and 12, Fig. V-32 a & b).

(g) Loosen the probe lock-nut and remove the probe from the barrel attenuator (Ref. 6 and 13, Fig. V-32 a & b). The barrel assembly (Ref. 12, Fig. V-32 a & b) is now free and clear. Hold the barrel to a light and sight through it and inspect closely for dust specks. Use a magnifying glass for this purpose. Clean

the inside of the barrel with a lint-free cloth or tissue paper dampened with an approved solvent. Reinspect for dust or lint particles. Make sure the barrel is absolutely clean before reassembly.

(h) Inspect the choke assembly for wear and for cracks in the ferrite absorber ring. A cracked ring should be replaced.

Check the condition of the teflon inner liner.

Check the condition of the absorbers in the slots. They should be securely in place and flush with the metal surfaces.

(i) Inspect the condition of the inner conductor assembly, it should be smooth and clean.

Check that the repeller contact pin in the interior of the center conductor is in good condition.

Using a very light pressure, roll the fingered end of the conductor between the palm of one hand and a table top to compress and equalize the tension of the fingers.

CAUTION

Do not use too much pressure. It is sufficient to straighten the alignment of the fingers so that they will grip evenly about the grid of the klystron tube.

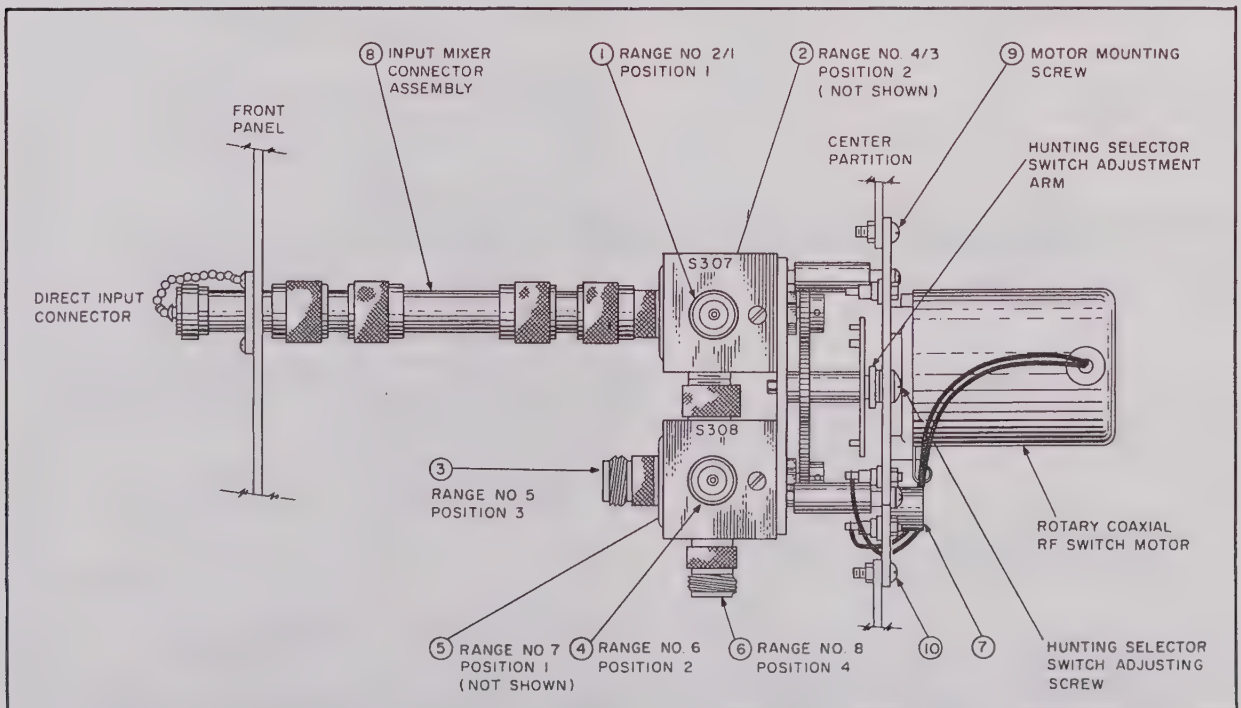


Figure V-34. Rotary Coaxial Switches (S307 and S308) for Serial Numbers 251 and up.

NOTE

5721 Center Conductor assemblies in units with serial nos. 400 and up have internal spring fingers which do not require resetting.

(j) Assemble the choke and center conductor. Align the push rods with the mark made in step (a) above and insert the center conductor into the barrel. Fasten the center conductor in place with the rear lock nut.

(k) Check the condition of the contact ring. It should not be deformed and all three ears should display equally worn rub marks. If necessary, reform the ring by pressing it in an arbor or a vise.

(l) Place the contact ring in the barrel breech. Insert the wedge ring, thick edge first, into the breech as far as it will go. Slide the retainer ring over the new klystron tube with its thick edge facing the tube base. Holding the tube and retainer ring with the fingers of one hand, insert the tip of the tube into the spring fingers of the center conductor. Press the tube in firmly as far as it will go using a slightly twisting motion, taking care not to slip and break the tube.

(m) When the klystron tube is firmly seated, push the retainer ring as far in as it will go and then install the retaining lock-nut and tighten it securely by hand.

(n) Install the end bell assembly by first connecting the socket to the tube base. Then, twisting the assembly approximately 1/2 turn to relieve the pressure of the socket leads from the tube base, install the end bell on the lock-nut with its tube facing approximately 45° counterclockwise from the probe attenuator.

Install the end bell clamp and tighten securely.

NOTE

For the cavity assemblies supplied with the magnetic shield, proceed as follows:

(1) Slide the upper half into place over the cooling fins as far as it will go.

(2) Place the lower half over the end bell assembly with the locking end upwards.

(3) Connect the klystron socket to the tube base and push the end bell over the finned lock-nut.

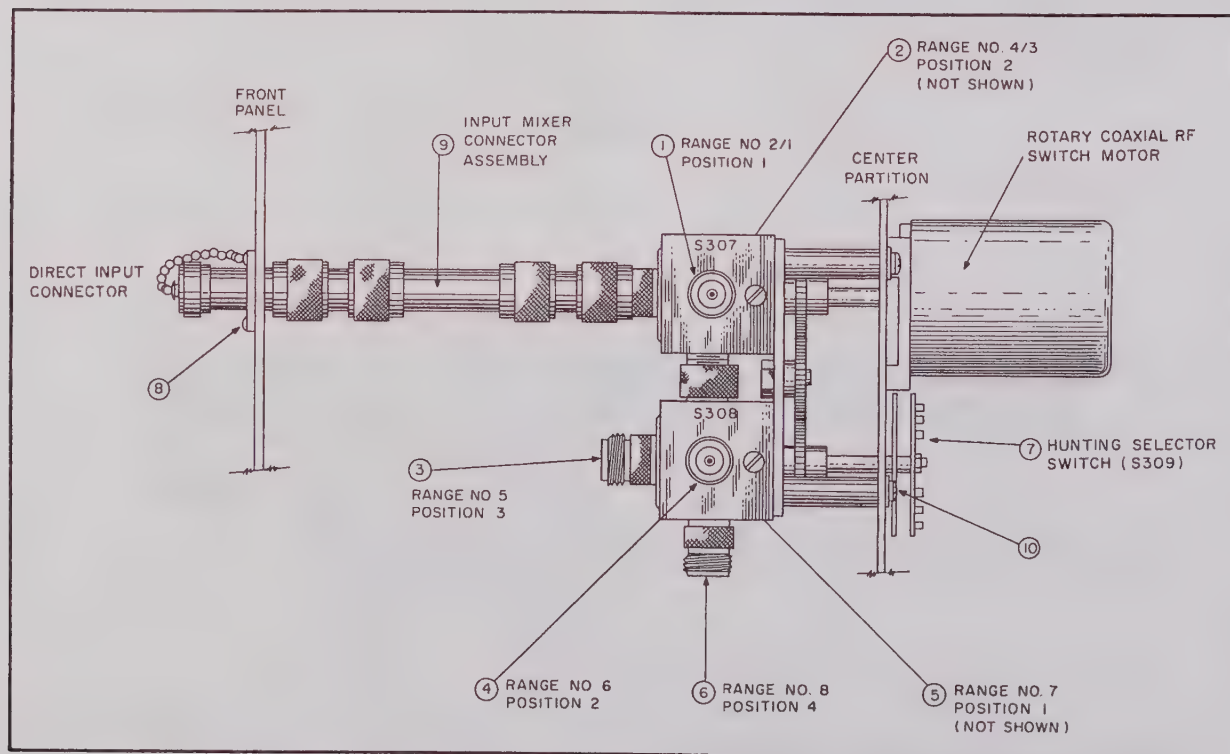


Figure V-35. Rotary Coaxial RF Switches (S307 and S308) For Serial Numbers 201-250.

(4) Lock the lower and upper halves of the shield together with a twisting motion. Twist the end bell 45° counterclockwise from the probe attenuator. If the fit is too loose, disassemble the end bell and shield and press the notched end of the end bell inward and repeat the above instructions.

3. Replacement of the 5721 Cavity Assembly.

(a) Replace the Cavity assembly in the same position and orientation as before it was removed. (The Cavity Attenuator Barrel facing the rear and to the right at approximately 45°.)

(b) Place the Cavity assembly into its casting being sure that the cables along the bottom are out of the way.

NOTE

The stop-washers, located on the TUNING knob shaft, may have to be rotated so that they do not touch the Cavity assembly.

(c) Move the Drive Rod up for easier installation of the Cavity assembly.

(d) Mount the Cavity mounting-clamp (ref. 20, Fig. V-25) tightening the two mounting screws hand-tight. This will enable the Cavity assembly to be held in position and loose enough for minor adjustments.

(e) Replace the cavity lock (ref. 21, Fig. V-25b) being sure that it does not touch the yoke or push rods. (For Ser. Nos. 251-up only).

(f) Tighten the cavity mounting-clamp mounting screws.

(g) Replace the center frequency adjustment screw with the tension spring (ref. 16, Fig. V-25) between the yoke and crossbar. The tension spring should have its wider end resting on the yoke.

(h) Solder the repeller voltage lead to the red MOD jack. (ref. 4 Fig. V-25).

(i) Replace the Potentiometer mounting board.

(j) Connect the power plug P312 to J312. (ref. 18, Fig. V-25).

(k) Connect the output plug (ref. 2, Fig. V-30) to the Rotary Coaxial RF Switch (S308).

k. TROUBLESHOOTING OF THE ROTARY CO-AXIAL RF SWITCHES (S307 AND S308).

Reference figure V-34

(For Serial Nos. 251 and up)

Reference figure V-35

(For Serial Nos. 201-250)

Reference figure V-36

(For Serial Nos. 151-200)

1. If the Rotary Coaxial RF Switches are suspected of being faulty, (refer to par V-2.d. Troubleshooting Chart, steps 24 and 27), perform the following procedure.

NOTE

The ohmmeter leads used in this procedure should have Type "N" adapters on one end so that they can be screwed onto the Rotary Coaxial RF Switch connector receptacles. The continuity resistance should be less than 0.2 ohm.

(a) Connect one ohmmeter lead to the DIRECT INPUT connector on the front panel of the Tuning Head.

(b) Press the RANGE pushbutton #2/1 and check for continuity at position 1, switch S307 (ref. 1). Ohmmeter should indicate continuity.

(c) Press the RANGE pushbutton #4/3 and check for continuity at position 2, switch S307 (ref. 2). Ohmmeter should indicate continuity.

(d) Press the RANGE pushbutton #5 and check for continuity at position 3, switch S308 (ref. 3). Ohmmeter should indicate continuity.

(e) Disconnect the ohmmeter lead from the DIRECT INPUT connector on the front panel. The following continuity measurements will be taken in reference to position 3 of switch S308 (ref. 3).

(f) Press the RANGE pushbutton #6 and check for continuity at position 2 of switch S308 (ref. 4). Ohmmeter should indicate continuity.

(g) Press the RANGE pushbutton #7 and check for continuity at position 1 of switch S308 (ref. 5). Ohmmeter should indicate continuity.

(h) Press the RANGE pushbutton #8 and check for continuity at position 4 of switch S308 (ref. 6). Ohmmeter should indicate continuity.

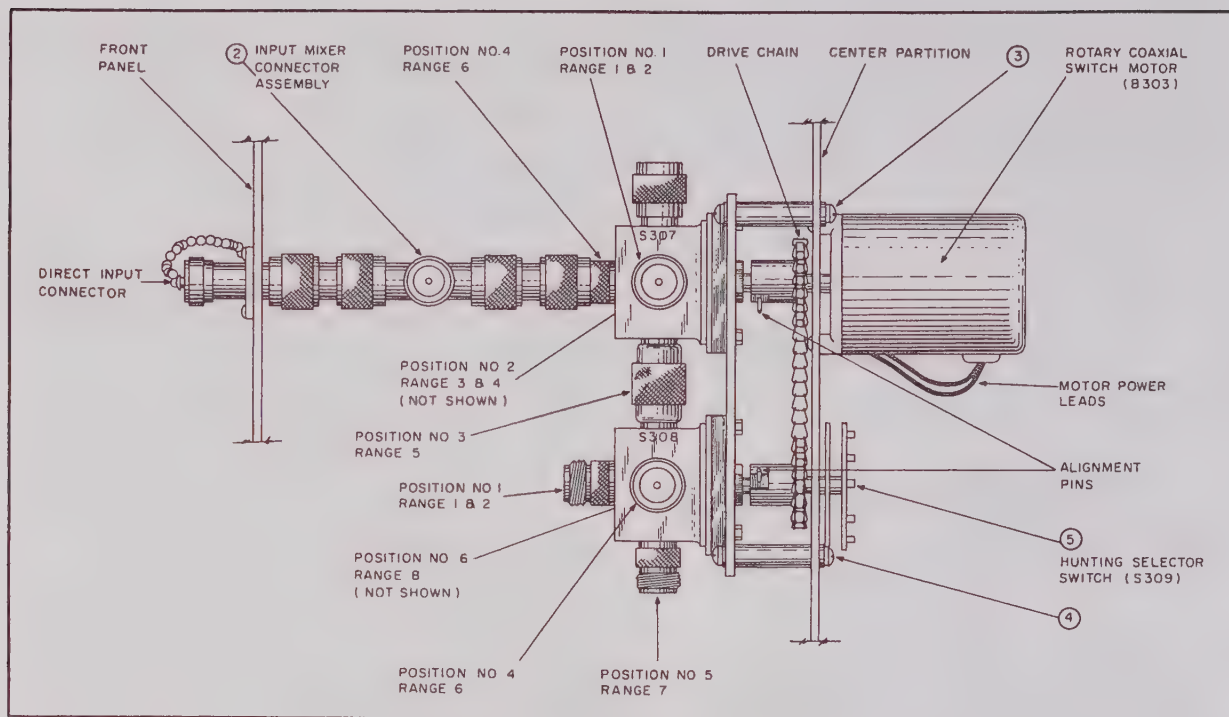


Figure V-36. Rotary Coaxial RF Switch Assembly (Serial Numbers 151-200).

(i) If continuity cannot be obtained at all switch positions, removal of the entire coaxial switch assembly (including motor) may be necessary. Return to the factory for repair.

2. Procedure for Removal and Replacement of Rotary Coaxial RF Switch Assembly (Serial nos. 251 and up). Reference Figure V-34.

(a) Remove plug from receptacle (ref. 7) at rear of coaxial switch assembly.

(b) Remove all coaxial switch cable connections.

(c) Remove Input Mixer Connector Assembly (ref. 8) from coaxial switch S307.

(d) Remove the two mounting screws holding motor plate to chassis (ref. 9 and 10).

(e) Remove the two screws that hold the hinged back panel to the Tuning Head. This will allow the hinged back panel to drop out of the way for easier removal of the coaxial switches.

(f) To replace the Rotary Coaxial RF Switch assembly, reverse the above procedure.

3. Procedure for Removal and Replacement of the Rotary Coaxial RF Switch Assembly (Serial nos. 201-250) Reference Figure V-35.

(a) Remove all coaxial switch cable connections.

(b) Disconnect and tag all Hunting Selector Switch (S309) soldered connections (Ref. 7).

(c) Disconnect and tag rotary switch motor leads.

(d) Remove the four mounting screws (ref. 8) to loosen the DIRECT INPUT connector on the front panel.

(e) Remove the four screws which hold the center partition in place. This will allow the center partition to be moved back for easier accessibility of the INPUT Mixer Connector assembly.

(f) Remove the INPUT Mixer Connector assembly (ref. 9).

(g) Remove the two screws which hold the hinged back panel in place. Drop the hinged back panel for easier removal of the Rotary Coaxial RF Switch assembly.

(h) Remove the four mounting post screws (ref. 10) which hold the Rotary Coaxial RF Switch assembly to the center partition.

(i) Remove the Rotary Coaxial RF Switch assembly.

(j) To replace the Rotary Coaxial RF Switch assembly, first set the Hunting Selector Switch (ref. 7) to position 3, which is the common position of the rotary switches, and reverse the above procedure. Check that the alignment pins on the rotary switch shafts are also set to position 3 (common) and are properly mated to the gears.

4. Procedure for Removal and Replacement of the Rotary Coaxial RF Switch Assembly. (Serial nos. 151-200) Reference Figure V-36.

(a) Remove all coaxial switch cable connections.

(b) Remove the four mounting screws to loosen the DIRECT INPUT connector on the front panel for easier removal of the INPUT MIXER connector assembly.

(c) Remove the INPUT MIXER connector assembly (ref. 2).

(d) Remove the two screws which hold the hinged back panel in place. Drop the hinged back panel for easier accessibility of the Rotary Coaxial RF Switch assembly.

(e) Remove the four mounting post screws (ref. 3 and 4) which hold the Rotary Coaxial RF Switch assembly to the center partition. The rotary switch assembly can now be disengaged from the drive chain assembly.

(f) Disconnect and tag the two motor power leads.

(g) Remove the four motor mounting screws.

(h) To replace the Rotary Coaxial RF Switch assembly, first set the Hunting Selector Switch (ref. 5) to position 3, which is the common position of the rotary switches and reverse the above procedure. Check that the alignment pins on the rotary switch shafts are also set to position 3 (common) and are properly mated to the chain drive gears.

V-5. VOLTAGE AND RESISTANCE CHARTS

a. NOTES PERTAINING TO VOLTAGE AND RESISTANCE CHARTS.

1. Conditions of measurement.

(a.) All measurements were taken under normal operating conditions using extension cables and removing chassis shields when necessary.

Unless specified by a Note on the Charts, operating controls were set as follows:

SWEEP RATE Synchronized at 30 cps.
IF BANDWIDTH Maximum clockwise
SWEEP WIDTH CONT Maximum clockwise
VIDEO FILTER OUT
AMPLITUDE SCALE LIN
RANGE 10 MC - 1 KMC

Other controls - BRILLIANCE, FOCUS, GAIN, etc. - were at normal operating positions. Line voltage set at 115 VAC.

(b.) All measurements were taken with respect to ground, using a vacuum tube voltmeter (such as RCA VoltOhmyst WV-77E), unless specified by the following notes on the Charts.

2. RANGE switch set to 1-4.5 KMC.

3. RANGE switch set to 4.5-11 KMC.

4. SWEEP WIDTH RANGE set to 0-70 MC.

5. SWEEP WIDTH RANGE set to 0-5 MC.

6. Sawtooth voltage is being measured. Two voltage values are given. The first, single reading, is the average value indicated on the vacuum tube voltmeter when SWEEP RATE is set to 30 cps. The second, dual reading, is the range of voltage indicated on the vacuum tube voltmeter when SWEEP RATE is set to 1 cps. These conditions are specified by SAW in the appropriate tube pin column.

7. Measurements on T101, C101, C103 and where note is referenced, require the use of 20,000 ohm per volt multimeter (such as the Triplett Model 630), or other ungrounded meter, capable of measuring 3000 volts A.C. and 5000 volts D.C.

8. Pins 1, 2, 3 and 4 are accessible at J308 (V302, 6BM6) and at J312 (V304, 5721), from the bottom of the R. F. Tuning Head. Plate leads are accessible at Red test points on the R.F. potentiometer board.

9. The following resistive loads were used for Power Supply measurements. (See Fig. V-38).

300 volt load connected to pin 3 of C 127.

Value - 1000 ohms, 100 watts.

200 volt load connected to pin 5 of C127

Value - 1000 ohms, 50 watts.

-325 volt load connected to pin 5 of V108

Value - 12.2 K, 15 watts.

-1250 volt load connected to pin 5 of V108

Value - 67.5 K, 20 watts

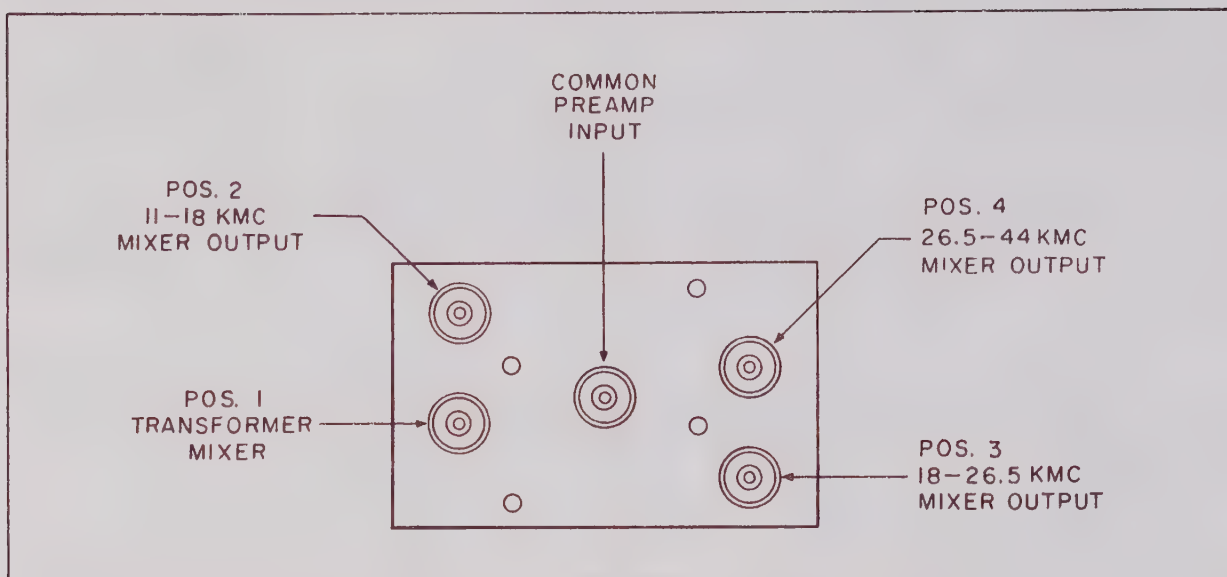


Figure 5-37. Front View, Coaxial Switching Relay K301

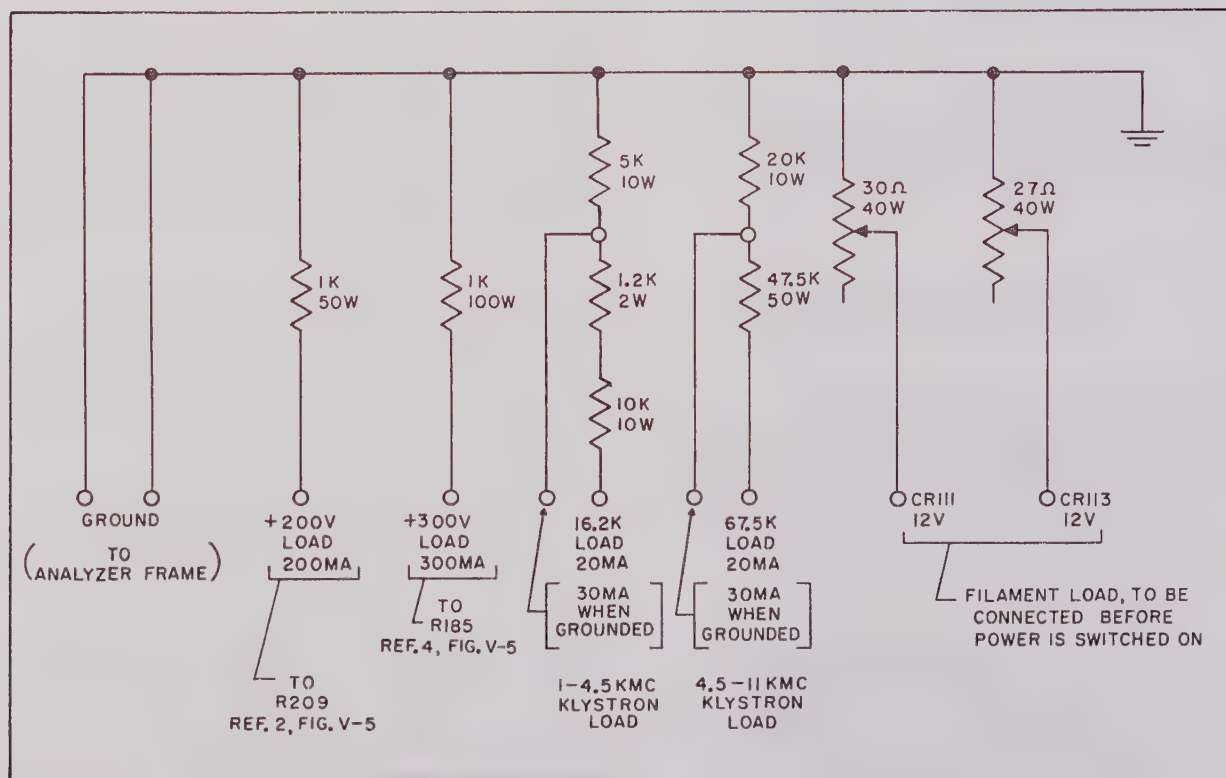


Figure 5-38. Power Supply Dummy Load

VOLTAGE AND RESISTANCE CHART FOR MODEL SPA -4a
POWER SUPPLY

Circuit Ref. Symbol		Type		PIN NUMBERS																				NOTES	
				1		2		3		4		5		6		7		8		9					
				V	R	V	R	V	R	V	R	V	R	V	R	V	R	V	R	V	R				
V101	5R4	NC	NC	600 VDC 840 VDC	2.6 M 2.6 M	NC	NC	430 VAC 500	1.5 M 1.5 M	NC	NC	430 VAC 560 VAC	6.5 M	NC	NC	NC	600 VDC 840 VDC	2.6 M 2.6 M				2,7 3,7			
V102	5R4	NC	NC	-160 VDC -500 VDC	1.5 M 1.5 M	NC	NC	-940 VDC -1900 VDC	500 K 480 K	NC	NC	-940 VDC -1900 VDC	500 K	NC	NC	NC	-160 VDC -500 VDC	1.5 M 1.5 M				2,7 3,7			
V103	6146	NC	NC	6 VDC	4 Ω	NC	195 VDC	O	4 Ω	-50 VDC -48 VDC	160 K 162 K	O	4 Ω	O	4 Ω	O	O	∞				2 3			
V104	6146	NC	NC	6 VDC	4 Ω	NC	195 VDC	O	4 Ω	-50 VDC -48 VDC	160 K 162 K	O	4 Ω	O	4 Ω	O	NC	NC				2 3			
V105	12AT7	-150 VDC	50 K	-230 VDC	75-85 K	500 K	-230 VDC	-145 VDC	∞	-145 VDC	∞	-150 VDC	6.2 K	52 K	-150 VDC	-145 VDC	∞	-145 VDC	∞						
V106	OA2	NC	NC	-145 VDC	∞	NC	NC	NC	NC	O	4 Ω	NC	NC	NC	NC	NC									
V107	OG3	-145 VDC	∞	-230 VDC	430 K	NC	NC	NC	NC	-145 VDC	∞	NC	NC	-230 VDC	530 K										
V108	OA2	NC	NC	-470 VDC -1400 VDC	430 K 430 K	NC	NC	NC	NC	-325 VDC -1250 VDC	410 K 410 K	NC	NC	NC	NC	NC						2,7 3,7			
V109	OA2	NC	NC	-620 VDC -1550 VDC	400 K 450 K	NC	NC	NC	NC	-470 VDC -1400 VDC	430 K 430 K	NC	NC	NC	NC	NC						2,7 3,7			
V110	OA2	NC	NC	-760 VDC -1700 VDC	400 K 470 K	NC	NC	NC	NC	-620 VDC -1550 VDC	450 K 450 K	NC	NC	NC	NC	NC						2,7 3,7			
V111	OA2	NC	NC	-920 VDC -1550 VDC	500 K 490 K	NC	NC	NC	NC	-760 VDC -1700 VDC	470 K 470 K	NC	NC	NC	NC	NC						2,7 3,7			
V112	6AS7	200 VDC*	2 M	420 VDC	900 K	500 K	300 VDC	200 VDC*	2 M	420 VDC	900 K	300 VDC	500 K	100 K	110 VDC	100 K									
V113	6AS7	200 VDC*	2 M	420 VDC	900 K	500 K	300 VDC	200 VDC*	2 M	420 VDC	900 K	300 VDC	500 K	100 K	110 VDC	100 K									
V114	12AX7	300 VDC	500 K	105 VDC	2 M	100 K	115 VDC	115 VDC	100 K	115 VDC	100 K	200 VDC*	2 M	105 VDC	1 M	115 VDC	100 K	115 VDC	100 K						
V115	12AX7	105 VDC	1 M	O	100 K	230 K	1 VDC	115 VDC	100 K	115 VDC	100 K	105 VDC	1 M	O	O	1 VDC	230 K	115 VDC	100 K						
V116	6AS7	130 VDC*	2 M	295 VDC	500 K	300 K	200 VDC	130 VDC*	2 M	295 VDC	500 K	200 VDC	300 K	100 K	40 VDC	40 VDC	100 K								
V117	12AX7	200 VDC	300 K	32 VDC	1 M	100 K	40 VDC	40 VDC	100 K	40 VDC	100 K	130 VDC*	2 M	32 VDC	1 M	40 VDC	100 K	40 VDC	100 K						
V118	12AX7	32 VDC	1 M	O	100 K	240 K	.3 VDC	40 VDC	100 K	40 VDC	100 K	32 VDC	1 M	O	O	.3 VDC	240 K	40 VDC	100 K						
V119	OA2	O	O	NC	NC	NC	NC	-145 VDC	20 K	NC	NC	NC	NC	NC	-145 VDC	20 K									
V120	5651	O	O	-85 VDC	40 K	NC	NC	-85 VDC	40 K	NC	NC	NC	NC	NC	-85 VDC	40 K									
V121	6AR6	2.5 VDC	100 Ω	NC	NC	∞	295 VDC	NC	NC	125 VDC	∞	O	∞	-95 VDC	100 K	6 VAC	∞		PLATE	CAP					
V122	1X2B	2400 VDC	∞	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	2400 VDC	∞	NC	DNM	27	7				
V123	1X2B	DNM	25 Ω	DNM	27 Ω	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	-2400 VDC	20 M	7				

* = BREAKS OUT OF REGULATION

∞ = INFINITE

NC = NO CONNECTION

DNM = DO NOT MEASURE

All power cables disconnected.

Resistive loads used for measurements. See note 9 for values.

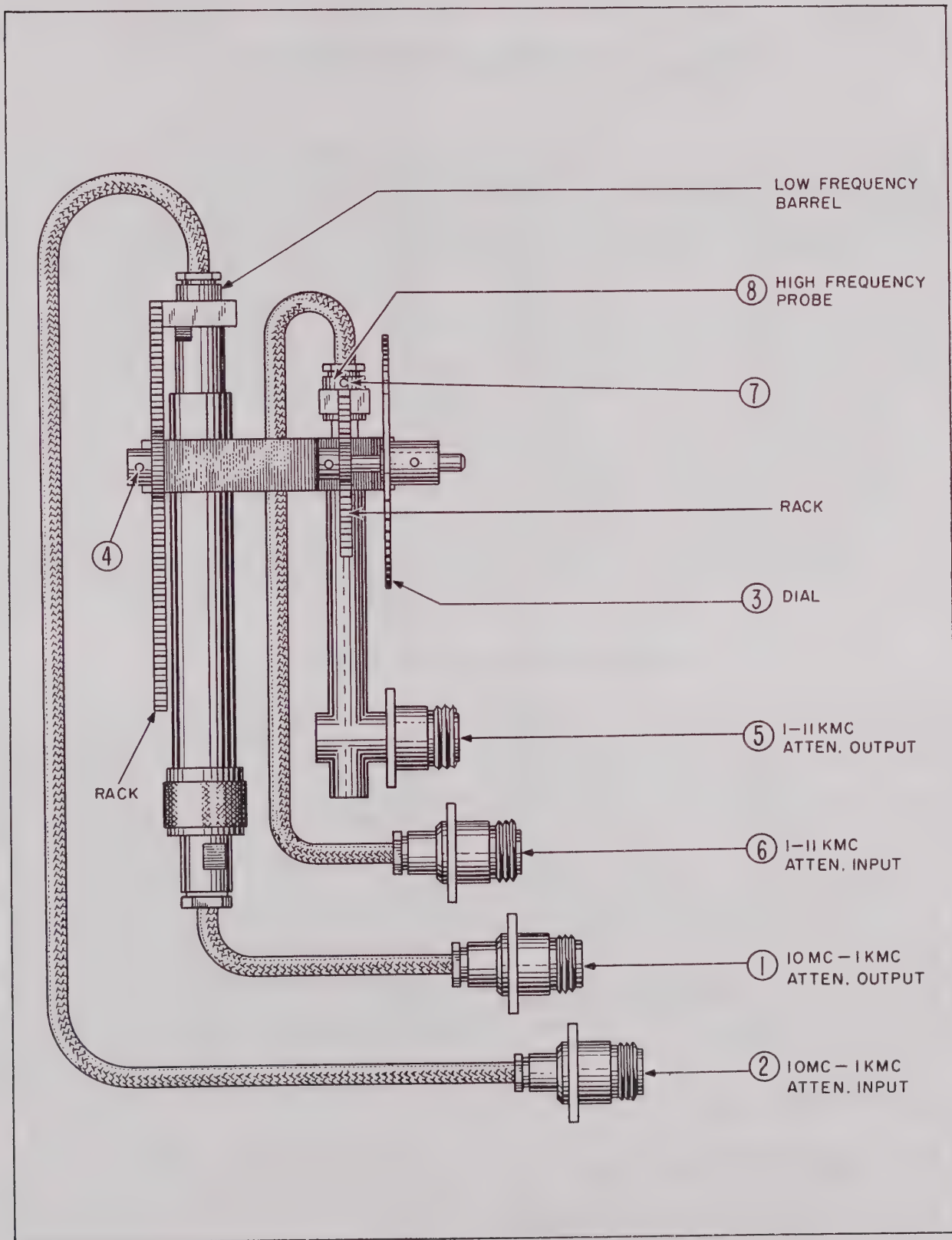


Figure V-39. R.F. Attenuator Assembly

VOLTAGE AND RESISTANCE CHART FOR MODEL SPA-4a
CHASSIS 75 MC IF AMPLIFIER (Ser. Nos. 151 - 250)

CIRCUIT REF. SYMBOL	TYPE	PIN NUMBERS								
		1		2		3		4		
		V	R	V	R	V	R	V	R	
V1001	6CB6	O	O	1.3 VDC	180 Ω	O	O	5.6 VAC	.1 Ω	
V1002	6CB6	O	3 K	1.3 VDC	180 Ω	O	O	5.6 VAC	.1 Ω	
V1003	6CB6	O	5.1 K	1.4 VDC	180 Ω	O	O	5.6 VAC	.1 Ω	
V1004	6CB6	O	5.6 K	1.5 VDC	180 Ω	O	O	5.6 VAC	.1 Ω	
V1005	6AL5	O	O	-.25 VDC	10 K	O	O	5.6 VAC	.1 Ω	
V1006	6BA7	90 VDC	28 K	-.05 VDC	22 K	.9 VDC	68 Ω	O	O	
V1007	12AT7	245 VDC	17 K	O	100 K	1.75 VDC	240 Ω	O	O	
V1008	6AH6	-.25 VDC	10 K	1.6 VDC	160 Ω	O	O	5.6 VAC	.1 Ω	
V1009	6AB4	270 VDC	11 K	O	O	O	O	5.6 VAC	.1 Ω	

75 MC IF AMPLIFIER (Ser. Nos. 251 - up)

V1001	6CB6	O	O	1.3 VDC	170 Ω	O	∞	5.8 VAC	∞	
V1002	6CB6	O	3 K	1.3 VDC	170 Ω	O	∞	5.8 VAC	∞	
V1003	6CB6	O	5 K	1.35 VDC	170 Ω	O	∞	5.8 VAC	∞	
V1004	6CB6	O	5.6 K	1.75 VDC	170 Ω	O	∞	5.8 VAC	∞	
V1005	6AL5	O	O	-.25 VDC	10 K	O	∞	5.8 VAC	∞	
V1006	6BA7	80 VDC	130 K	O	20 K	.83 VDC	68 Ω	O	∞	
V1007	12AT7	230 VDC	100 K	O	100 K	1.9 VDC	240 Ω	O	∞	
V1008	6AH6	-.25 VDC	10 K	1.83 VDC	160 Ω	O	∞	5.8 VAC	∞	
V1009	6AB4	260 VDC	100 K	O	O	O	∞	5.8 VAC	∞	

∞ = INFINITE

NC = NO CONNECTION

DNM = DO NOT MEASURE

* = BREAKS OUT OF REGULATION

VAR = VARIES WITH SETTING OF CONTROL

PIN NUMBERS										
	5		6		7		8		9	
	V	R	V	R	V	R	V	R	V	R
	210 VDC	13 K	105 VDC	75 K	O	O				
	215 VDC	12 K	108 VDC	74 K	O	O				
	230 VDC	11 K	110 VDC	73 K	O	O				
	255 VDC	10 K	135 VDC	72 K	1.5 VDC	180 K				
	-.1 VDC	∞	O	O	-.1 VDC	∞				
	5.6 VAC	.1 Ω	O	O	1.5 VDC	5.6 K	O	O	240 VDC	13 K
	O	O	245 VDC	17 K	O	51 Ω	1.6 VDC	240 Ω	5.6 VAC	.1 Ω
	190 VDC	21 K	160 VDC	62 K	1.6 VDC	160 Ω				
	NC	NC	O	100 K	2.3 VDC	300 Ω				

	205 VDC	100 K	102 VDC	150 K	O	O				
	210 VDC	100 K	100 VDC	160 K	O	O				
	230 VDC	100 K	110 VDC	170 K	O	O				
	255 VDC	100 K	130 VDC	170 K	1.75 VDC	180 K				
	-.1 VDC	∞	O	O	-.1 VDC	∞				
	5.8 VAC	∞	O	O	-.03 VDC	5.6 K	O	O	230 VDC	100 K
	O	∞	230 VDC	100 K	O	51 Ω	1.9 VDC	240 Ω	5.8 VAC	∞
	165 VDC	100 K	150 VDC	150 K	1.8 VDC	160 Ω				
	NC	NC	O	100 K	2.6 VDC	300 Ω				

VOLTAGE AND RESISTANCE CHART FOR MODEL SPA-4a
CHASSIS, 160 MC NARROW BAND AMPLIFIER (Ser. nos. 151-250)

CIRCUIT REF. SYMBOL	TYPE	PIN NUMBERS									
		1		2		3		4			
		V	R	V	R	V	R	V	R		
V 801	6922	105 VDC	∞	8.6 VDC	15 K	10 VDC	680 Ω	O	O		
V 802	6688	10 VDC	620 Ω	8.6 VDC	22 K	NC	NC	5.6 VAC	0.1 Ω		
V 803	6688	10 VDC	620 Ω	8.6 VDC	27 K	NC	NC	5.6 VAC	0.1 Ω		
V 804	6J4	NC	NC	0.4 VDC	240 Ω	O	O	5.6 VAC	0.1 Ω		
V 805	12AT7	190 VDC	12 K	-0.8 VDC	15 K	O	O	-6.3 VDC	3 Ω		
V 806	6CB6	4.4 VDC	460 K	8.5 VDC	VAR. 1.5 K	-12.6 VDC	6 Ω	-6.3 VDC	3 Ω		

160 MC NARROW BAND AMPLIFIER (Ser. nos. 251 - up)

V 801	6922	100 VDC	∞	8.7 VDC	13 K	9.75 VDC	600 Ω	O	O		
V 802	6688	10 VDC	500 Ω	8.9 VDC	20 K	10 VDC	500 Ω	6 VAC	.2 Ω		
V 803	6688	10.2 VDC	500 Ω	8.75 VDC	24 K	10 VDC	500 Ω	6 VAC	.2 Ω		
V 804	6J4	-.25 VDC	460 K	+.4 VDC	200 Ω	O	O	-6 VDC	2 Ω		
V 805	12AT7	180 VDC	27 K	-.4 VDC	14 K	O	O	-6 VDC	2.6 Ω		
V 806	6CB6	-145 VDC	450 K	1.8 VDC	1 K	-12.6 VDC	4 Ω	-6 VDC	28 Ω		

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DNM = DO NOT MEASURE

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VAR = VARIES WITH SETTING OF CONTROL

PIN NUMBERS											
	5		6		7		8		9		NOTES
	V	R	V	R	V	R	V	R	V	R	
	5.6 VAC	0,1 Ω	200 VDC	12 K	100 VDC	55 K	105 VDC	∞	O	O	5
	O	O	NC	NC	200 VDC	18 K	O	O	165 VDC	22 K	5
	O	O	NC	NC	200 VDC	12 K	O	O	165 VDC	22 K	5
	-0.65 VDC	470 K	-0.65 VDC	470 K	50 VDC	18 K					5
	-6.3 VDC	3 Ω	200 VDC	12 K	O SAW -765.5 VDC	VAR 800 K	4.6 VDC	240 K	O	O	5,6
	+90 VDC	12 K	200 VDC	12 K	O	O					5

	6 VAC	.3 Ω	190 VDC	26 K	100 VDC	50 K	100 VDC	∞	O	O	
	O	O	O	∞	195 VDC	28 K	O	O	160 VDC	34 K	
	O	O	O	∞	210 VDC	28 K	O	O	175 VDC	34 K	
	-1.1 VDC	160 K	-1.1 VDC	460 K	48 VDC	17.5 K					
	-6 VDC	20 Ω	205 VDC	18.5 K	-2 VDC	700 K	-150 VDC	250 K	O	O	
	176 VDC	20 K	195 VDC	28 K	O	O					

VOLTAGE AND RESISTANCE CHART FOR MODEL SPA-4a
CHASSIS 160 MC WIDEBAND AMPLIFIER (Ser. Nos. 151 - 250)

CIRCUIT REF. SYMBOL	TYPE	PIN NUMBERS								
		1		2		3		4		
		V	R	V	R	V	R	V	R	
V405	6688	8.8 VDC	620 Ω	7.2 VDC	8.2 K	8.8 VDC	620 Ω	O	O	
V406	6688	8.8 VDC	620 Ω	7.2 VDC	13 K	8.8 VDC	620 Ω	O	O	
V407	6688	8.8 VDC	620 Ω	7.2 VDC	18 K	8.8 VDC	620 Ω	O	O	
V408	6688	8.8 VDC	620 Ω	7.2 VDC	8.2 K	8.8 VDC	620 Ω	O	O	
V409	6688	8.8 VDC	620 Ω	7.2 VDC	13 K	8.8 VDC	620 Ω	O	O	
V410	6688	8.8 VDC	620 Ω	7.2 VDC	18 K	8.8 VDC	620 Ω	O	O	
V601	6AQ5	O SAW -19 VDC to +14 VDC	700 K	5 to 26 VDC	VAR 3 K	-12.6 VDC	4 Ω	-6.3 VDC	2 Ω	
V603	6AF4A	90 to 100 VDC	∞	-4 VDC	51 K	O	O	-6.3 VDC	2 Ω	
V604	6AF4A	NC	NC	NC	NC	O	O	-6.3 VDC	2 Ω	
V605	6AQ5	130 to 150 VDC	210 K	140 to 155 VDC	∞	5.6 VAC	0.1 Ω	O	O	
V606	12AX7	195 VDC	220 K	-4 VDC	530 K	-1.75 VDC	1 K	O	O	

160 MC WIDEBAND AMPLIFIER (Ser. Nos. 251 - up)

V405	5842	145 VDC	18 K	O	∞	5 VAC	1.6 Ω	O	O	
V406	5842	145 VDC	20 K	O	∞	5.5 VAC	1 Ω	O	O	
V601	6AQ5	9 VAC	600 K	10.7 VAC 17 VDC	2.6 K	-12.5 VDC	3.8 Ω	-6 VDC	2 Ω	
V603	6AF4A	75 VDC	50 meg.	-3 VDC	40 K	O	O	-6 VDC	2 Ω	
V604	6AF4A	25 VDC	120 K	-2.5 VDC	460 K	O	O	-6 VDC	1.8 Ω	
V605	6AQ5	55 VDC	200 K	75 VDC	45 meg	6 VAC	.2 Ω	O	O	
V606	12AX7	150 VDC	200 K	-3 VDC	500 K	-1.7 VDC	800 Ω	O	O	

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NC = NO CONNECTION

DNM = DO NOT MEASURE

* = BREAKS OUT OF REGULATION

VAR = VARIES WITH SETTING OF CONTROL

PIN NUMBERS											NOTES
5		6		7		8		9			
V	R	V	R	V	R	V	R	V	R		
5.6 VAC	0.1Ω	NC	NC	200 VDC	17 K	O	O	170 VDC	27 K	4	
5.6 VAC	0.1Ω	NC	NC	200 VDC	17 K	O	O	170 VDC	27 K	4	
5.6 VAC	0.1Ω	NC	NC	200 VDC	17 K	O	O	170 VDC	27 K	4	
5.6 VAC	0.1Ω	NC	NC	200 VDC	17 K	O	O	170 VDC	27 K	4	
5.6 VAC	0.1Ω	NC	NC	200 VDC	17 K	O	O	170 VDC	27 K	4	
5.6 VAC	0.1Ω	NC	NC	200 VDC	17 K	O	O	170 VDC	27 K	4	
298 VDC	9.4 K	198 VDC	18 K	NC	NC					4,6	
O	O	-4 VDC	51 K	90 to 100 VDC	∞					4,6	
O	O	-1.4 to -.2 VDC	430 K	22 to 27 VDC	130 K					4,6	
300 VDC	9 K	300 VDC	9 K	NC	NC					4,6	
O	O	131 to 151 VDC	210 K	8.4 to 10.6 VDC	VAR 480 K	O	O	5.6 VAC	0.1Ω	4,6	

O	O	1.25 VDC	55 Ω	O	O	O	O	O	.8 Ω	
O	O	1.25 VDC	50 Ω	O	O	O	O	O	.4 Ω	
300 VDC	6 K	200 VDC	18 K	9 VAC	500 K					
O	O	-2 VDC	44 K	75 VDC	50 meg					
O	.3 Ω	-1.2 VDC	400 K	25 VDC	100 K					
300 VDC	7 K	300 VDC	7 K	55 VDC	200 K					
O	O	55 VDC	200 K	.35 VDC	700 K	O	O	6 VAC	.2 Ω	

VOLTAGE AND RESISTANCE CHART FOR MODEL SPA-4a
CHASSIS 6.5 MC IF AMPLIFIER

CIRCUIT REF. SYMBOL	TYPE	PIN NUMBERS								
		1		2		3		4		
		V	R	V	R	V	R	V	R	
V1101	6CB6	O	1 MEG	1.6 VDC	190 Ω	O	∞	5.8 VAC	∞	
V1102	6AB4	290 VDC	28 K	NC	NC	O	∞	5.8 VAC	∞	
V1103	6CB6	O	2 Ω	1.75 VDC	180 Ω	O	∞	5.8 VAC	∞	
V1104	6AB4	290 VDC	28 K	NC	NC	O	∞	5.8 VAC	∞	
V1105	6CB6	O	2 Ω	1.65 VDC	180 Ω	O	∞	5.8 VAC	∞	
V1106	6AH6	O	50 K	1.85 VDC	160 Ω	O	∞	5.8 VAC	∞	
V1107	6AL5	.25 VDC	100 K	-.25 VDC	50 K	O	∞	5.8 VAC	∞	

VIDEO AMPLIFIER

V1201	12AY7	105 VDC	70 K	5 VDC	36 K	4.7 VDC	750 Ω	5.8 VAC	∞	
V1202	12AU7	190 VDC	65 K	O	33 K	10 VDC	5 K	5.8 VAC	∞	
V1203	6CB6	-0.7 VDC	480 K	O	O	5.8 VAC	∞	O	∞	

HORIZONTAL SWEEP

V1301	12AT7	35 VDC	1 M	-.4 VDC	140 K	.3 VDC	1 K	5.7 VAC	∞	
V1302	6CB6	1 VAC	900 K	O	O	5.7 VAC	∞	O	∞	
V1303	6AB4	300 VDC	18 K	NC	NC	5.7 VAC	∞	O	∞	
V1304	12AU7	225 VDC	230 K	O	1.6 M	36 VDC	6 K	3.7 VAC	∞	

CHASSIS 160 MC PREAMPLIFIER

V401	5842	145 VDC	18 K	NC	NC	5.4 VAC	0.8 Ω	O	O	
V402	5842	145 VDC	18 K	NC	NC	5.4 VAC	0.8 Ω	O	O	

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DNM = DO NOT MEASURE

* = BREAKS OUT OF REGULATION

VAR = VARIES WITH SETTING OF CONTROL

PIN NUMBERS											NOTES
5		6		7		8		9			
V	R	V	R	V	R	V	R	V	R		
260 VDC	30 K	120 VDC	90 K	1.6 VDC	170 Ω						
NC	NC	.8 VDC	1 M	3 VDC	340 Ω						
255 VDC	30 K	135 VDC	90 K	1.75 VDC	180 Ω						
NC	NC	.8 VDC	1 M	3 VDC	340 Ω						
255 VDC	30 K	130 VDC	90 K	1.65 VDC	180 Ω						
280 VDC	30 K	110 VDC	13.5 K	1.85 VDC	160 Ω						
O	2 Ω	O	O	O	2 Ω						

5.8 VAC	∞	130 VDC	60 K	O	4 MEG	.9 VDC	200	O	∞	
5.8 VAC	∞	300 VDC	17 K	160 VDC	150 K	200 VDC	50 K	O	∞	
290 VDC	65 K	25 VDC	10 K	O	O					

5.7 VAC	∞	165 VDC	230 K	-14 VDC	1 M	1.75 VDC	3 K	O	∞	
135 VDC	500 K	25 VDC	10 K	O	O					6
NC	NC	135 VDC	480 K	135 VDC	30 K					6
5.7 VAC	∞	100 VDC	230 K	19 VDC	160 K	25 VDC	5.6 K	O	∞	6

O	O	1.45 VDC	62 Ω	O	O	O	O	1.42 VDC	0.2 Ω	
O	O	1.45 VDC	62 Ω	O	O	O	O	1.42 VDC	0.2 Ω	

CATHODE-RAY TUBE

CIRCUIT REF. SYMBOL	TYPE										
		PIN 1		PIN 2		PIN 3		PIN 4			
		V	R	V	R	V	R	V	R		
V1401	5ADP1	-2300 VDC	15 M	-2300 VDC	15 M	-2300 VDC	15 M	NC	NC		
		PIN 8		PIN 9		PIN 10		PIN 11			
		150 VDC	240 K	175 VDC	56 K	220 VDC	60 K	145 VDC	55 K		

TUNING HEAD

CIRCUIT REF. SYMBOL	TYPE	PIN NUMBERS									
		1		2		3		4			
		V	R	V	R	V	R	V	R		
V301	6AF4	30 VDC	O	VAR .2 to 9.2 VDC	2350 Ω	-5.2 VDC	8.8 Ω	O	.2 Ω		
V302	6BM6	VAR -305 VDC	∞	-320 VDC	∞	-320 VDC	∞	-310 VDC	∞		
V304	5721	VAR -1240	∞	-1200 VDC	∞	-660 VDC	∞	-1200 VDC	∞		

ADDITIONAL VOLTAGE & RESISTANCE MEASUREMENTS, POWER SUPPLY

CIRCUIT REF. SYMBOL	TEST POINT	V	R	NOTES
T101	LUG 10 to LUG 12	1200 VAC	850 Ω	2,7
		2150 VAC	850 Ω	3,7
	LUG 7 to LUG 9	1200 VAC	850 Ω	2,7
		2150 VAC	850 Ω	3,7
C101	ACROSS TERMINALS	750 VDC	1 M	2,7
		1300 VDC	1 M	3,7
C103	ACROSS TERMINALS	750 VDC	1 M	2,7
		1300 VDC	1 M	3,7
J317 J319	ACROSS JACKS	VAR 12 VDC	2.5 K	3,7
J313 J315	ACROSS JACKS	O	5.6 K	2,7

							NOTES
PIN 5		PIN 6		PIN 7			
V	R	V	R	V	R		
-1300 VDC	10 M	NC	NC	160 VDC	230 K	7	
PIN 12		PIN 13		PIN 14			
NC	NC	NC	NC	-2300 VDC	15 M		

PIN NUMBERS							PLATE CAP	NOTES
5		6		7				
V	R	V	R	V	R			
O	.2 Ω	VAR .2 to 9.2 VDC	2350 Ω	30 VDC	O			
						VAR -305 VDC	2,8	
						VAR -1240 VDC	3,8	

V-6. GAIN MEASUREMENTS CHARTS

a. NOTES PERTAINING TO GAIN MEASUREMENT CHARTS.

1. Conditions of measurements.

(a) All measurements were taken under normal operating conditions using extension cables and removing shields when necessary.

(b) All measurements were taken using the test equipment listed below.

- (1) Boonton RF Voltmeter - Model 91-C
- (2) Dumont Oscilloscope, Model 401
- (3) Hewlett-Packard Oscillator - Model 200 CD
- (4) Hewlett-Packard Signal Generator

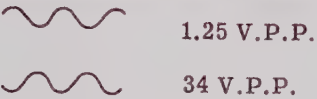
HORIZONTAL SWEEP GENERATOR

SYNC STAGES			VOLTAGE P-P	COMMENTS
STAGE		WAVE SHAPE		
INPUT	(12AT7) V1301 Pin 2		Distorted Sinewave 1.5 v	SYNC Signal 60~ INT.
OUTPUT	V1301 Pin 1		Distorted Sinewave 50 v.	
INPUT	(12AT7) V1301 Pin 7		50 v.	
OUTPUT	V1301 Pin 6		180 v.	
SHELL OF NEON TUBE SYNC. AMPL. MAX. CW			140 v.	

SAWTOOTH GENERATOR

STAGE		WAVE SHAPE	VOLTAGE P-P	COMMENTS
INPUT	(6CB6) V1302 Pin 1		150 mv	LINE SIZE fully clockwise
OUTPUT	V1302 Pin 5		60 v	
INPUT	(6AB4) V1303 Pin 6		60 v	HORIZONTAL POS. Adjusted to give max. undistorted output
SAWTOOTH OUT	V1303 Pin 7		SAWTOOTH OUT 60 v	
INPUT	(12AU7) V1304 Pin 2		5 v	
OUTPUT	V1304 Pin 1		HOR. OUT #2 160 v.	
INPUT	(12AU7) V1304 Pin 7		14 v.	
OUTPUT	V1304 Pin 6		HOR. OUT #1 120 v	

VIDEO AMPLIFIER GAIN MEASUREMENTS

STAGE	WAVE SHAPE	GAIN	COMMENTS
(12AY7) INPUT V1201 Pin 7 OUTPUT V1201 Pin 6		27.2	VERTICAL OUTPUT
(12AY7) INPUT V1201 Pin 2 OUTPUT V1201 Pin 1		15	VERT. POS. adjusted to give max. undistorted output VERTICAL OUTPUT
(12AU7) INPUT V1202 Pin 7 OUTPUT V1202 Pin 8		1.3	INTENSIFIER fully counterclockwise.
(12AU7) INPUT V1202 Pin 2 OUTPUT V1202 Pin 1		5	INTENSIFIER fully clockwise.
(6CB6) INPUT V1203 Pin 1 OUTPUT V1203 Pin 5		30	INTENSIFIER fully counterclockwise.
JUNCTION C1210 R1228			INTENSIFIER fully counterclockwise. INTENSITY OUTPUT
JUNCTION C1210 R1228			INTENSIFIER fully clockwise. INTENSITY OUTPUT. both signals 60 ~ VIDEO INPUT and HORIZONTAL OSC.
NOTE: Input 600 cps, 1.25 V. P-P, ASTIG. control max. CCW.			

75 MC IF GAIN MEASUREMENTS

STAGE	VOLTAGE	GAIN	COMMENTS
(6CB6) INPUT V1001 Pin 1 OUTPUT V1001 Pin 5	.0045 .009	2	Taken with GAIN control fully clockwise, max. gain. Gain from Input J1001 to Output J1003 is 7.7. Gain from Input J1001 to Output of 75 mc V1004 Pin 5 was 311. Measured with BOONTON RF VOLTMETER, MODEL 91-C
(6CB6) INPUT V1002 Pin 1 OUTPUT V1002 Pin 5	.009 .06	6.6	
(6CB6) INPUT V1003 Pin 1 OUTPUT V1003 Pin 5	.06 .09	1.5	
(6CB6) INPUT V1004 Pin 1 OUTPUT V1004 Pin 5	.09 1.4	15.5	
OUTPUT J1003	.035	J1001 to J1003 7.7	

SYNCHROSCOPE GAIN MEASUREMENTS

STAGE	VOLTAGE	GAIN	COMMENTS
(6AL5) INPUT V1005 Pin 5 OUTPUT V1005 Pin 3	Sinewave 10 mv Sinewave 8 mv	.8	Input to V1005 Pin 5 was H.P. Oscillator 200 CD 1000 cps, 10 mv output Measurements taken with Dumont Oscilloscope, Model 401, Readings = P - P
(6AH6) INPUT V1008 Pin 1 OUTPUT V1008 Pin 5	Sinewave 8 mv Sinewave 200 mv	250	
INPUT V1009 Pin 6 OUTPUT V1009 Pin 7	Sinewave 200 mv Sinewave 100 mv	.5	
OUTPUT - J1007	Sinewave 100 mv	V1005 pin 5 to J1004 GAIN 10	

6.5 MC IF GAIN MEASUREMENTS

STAGE	VOLTAGE	GAIN	COMMENTS
J1101 (6CB6) INPUT V1101 Pin 1 OUTPUT V1101 Pin 5	.001 .027	27	Measured in LIN position GAIN fully CW, max gain.
(6AB4) INPUT V1102 Pin 6 OUTPUT V1102 Pin 1	.018 .005	.28	Measured with BOONTON RF VOLTMETER, MODEL 91-C
(6CB6) INPUT V1103 Pin 1 OUTPUT V1103 Pin 5	.003 .23	73.	GAIN from J1101 to J1103 is 380.
(6AB4) INPUT V1104 Pin 6 OUTPUT V1104 Pin 1	.1 .037	.34	
(6CB6) INPUT V1105 Pin 1 OUTPUT V1105 Pin 5	.012 1.3	108	
(6AH6) INPUT V1106 Pin 1 OUTPUT V1106 Pin 5	.03 1.5	50	GAIN control of 6.5 mc turned CCW to reduce input to V1106 to .03 v.
(6AL5) INPUT V1107 Pin 7 OUTPUT V1107 Pin 2	1.5 .05	.032	
OUTPUT J1103	.38	Input to V1101 to .001 v.	

V-7. CABLE REPLACEMENT CHARTS

a. NOTES PERTAINING TO CABLE REPLACEMENT.

1. Conditions of cable replacement.

(a) All interconnecting cables listed in the Cable Replacement Chart should be connected and disconnected observing normal electrical safety procedures.

(b) Using the cable routing, symbol number and the correct equipment serial number,

the user is provided with a fast and accurate cable replacement guide. For further aid, refer to Fig. V-37 for relay cable connections.

CAUTION

All conhex type connectors are designed to be hand-tightened only. Do not use wrenches or pliers when removing or replacing cables.

CABLE REPLACEMENT CHART, INDICATOR MODEL I-4a

Ref. Sym. No.	C A B L E N U M B E R				From	To
	Ser. No. 151-200	Ser. No. 201-250	Ser. No. 251-300	Ser. No. 301 and up		
W401	W39-08	W39-08	W47-38	W113-38	J411 (K401A)	J407 (preamp)
W402	W39-06	W39-06	W47-6	W113-6	J409 (Wide Band Ampl)	J412 (K401A)
W403	W39-04	W39-04	W47-6P5	W113-6P5	J415 (K401A)	J417 (FL401)
W404	W39-01	W39-01	W39-4	W114-4	J419 (FL401)	J421 (FL403)
W405	W39-02	W39-02	W39-5	W114-5	J801 (Narrow Band Ampl)	J423 (FL403)
W601	W39-05	W39-05	W47-5	W113-5	J601 (Wide Band Ampl)	J425 (K401B)
W602	W41-04	W41-04	W102-37	W109-37	J603 (Wide Band Ampl)	R1361A (Sweep Width 0-07 Mc)
W701	W39-07	W39-07	W39-26	W114-26	CP701 (Wide J413 Band Ampl)	J701 (Marker Osc.)
W702	W39-010	W39-010	W39-53	W114-53	J707 (Marker Mod)	*J711 (Marker Mod Tuning Head)
W801	W47-01	W47-01	W47-11	W113-11	CP701 (Wide J413 Band Ampl)	J803 (Narrow Band Ampl)
W802	W39-03	W39-03	W47-6	W113-6	J427 (K401B)	J805 (Narrow Band Ampl)
W803	W41-02	W41-02	W102-37	W109-37	J807 (Narrow Band Ampl)	R1361B (Sweep Width 0-5 Mc)
W1001	W39-08	W39-010	W47-53	W113-53	J427 (K401B)	J1001 (75 mc I-F Ampl)
W1002	W39-09	W39-09	W39-40	W114-40	J1007 (75 mc I-F Ampl)	*J1012 (Synch- roscope Tuning Head)
W1101	W39-06	W39-06	W103-5P5	W110-6P5	J1003 (75 mc I-F Ampl)	J1101 (6.5 I-F Ampl)
W1103	W41-03	W41-03	W41-54	W112-54	J1301 Pin 3 (Hor Video)	*J1303 (Ext Sync Tuning Head)
W1201	W41-01	W41-01	W41-29	W112-29	J1103 (6.5 mc I-F Ampl)	J1301 Pin 16 (Hor Video)
W1203	-----	-----	W41-54	W112-54	J1301 Pin 6 (Hor Video)	J1203 (Y Axis Tuning Head)
W1207	-----	-----	W41-54	W112-54	J1301 Pin 14 (Hor Video)	*J1207 (Z Axis Tuning Head)
W1301	-----	-----	W41-54	W112-54	J1301 Pin 9 (Hor Video)	*J1307 (X Axis Tuning Head)

*Connects to rear panel mounting hole.

CABLE REPLACEMENT CHART, COMPOSITE TUNING HEAD MODEL RF-4a

Ref. Sym. No.	C A B L E N U M B E R				From	To
	Ser. No. 151-200	Ser. No. 201-250	Ser. No. 251-300	Ser. No. 301 and up		
W301	W45-01	W83-12	W98-12	W98-12	P311 (11-18 kmc Mixer Input)	P305 (S308, Pos. 6)
W303	W45-01	W83-12	W98-12	W98-12	P313 (18-26.5 kmc Mixer Input)	P307 (S308, Pos. 7)
W305	W45-01	W83-12	W98-12	W98-12	P315 (26.5 - 44 kmc, Mixer Input)	P309 (S308, Pos. 8)
W307	W46-01	W84-12	W99-12	W99-12	J329 (Trans- former Mixer)	J323 (K301, Pos. 1)
W309	W44-01	W82-12	W97-12	W97-12	△J317 (11 - 18 kmc Mixer Output)	J325 (K301, Pos. 2)
W311	W44-01	W82-12	W97-12	W97-12	△J319 (18 - 26.5 kmc, Mixer Output)	J327 (K301, Pos. 3)
W313	W44-01	W82-12	W97-12	W97-12	△J321 (26.5 - 44 kmc Mixer Output)	J328 (K301, Pos. 4)
W315	W46-01	W84-12	W99-12	W99-12	J405 (preamp Input)	J331 (K301 common)
W703	W40-03	W40-01	W40-21	W111-21	△CP703 (mar- ker Mod.)	*J711 (Marker Mod.)
W1003	W40-02	W40-02	W40-32	W111-32	△Synchro- scope Output	*J1012 (Synch- roscope)
W1102	W40-01	W40-01	W40-21	W111-21	△CP1305 (Ext. Sync.)	*J1303 (Ext. Sync.)
W1205	W40-02	W40-02	W40-32	W111-32	△Vertical	*J1203 (Y Axis)
W1209	W40-02	W40-02	W40-32	W111-32	△Z Axis	*J1207 (Z Axis)
W1307	W40-02	W40-02	W40-32	W111-32	△Horizontal	*J1307 (X Axis)

* Connects to rear panel mounting hole.

△ Located on front panel.

V-8. LIST OF REPLACEABLE PARTS

a. In the case where an item appears more than once, the total quantity per section is listed only once in the "Qty in Set" column. It is listed the first time the item appears.

b. A list of the Manufacturers Code Letters used in this list will be found at the end of this chapter.

c. In some cases, values and ratings and source (manufacturer) shown are nominal and variations

may be found. Satisfactory replacement may be made with either the listed component or an exact replacement for the part removed from the equipment.

When ordering parts from the factory, always include the following information:

1. Instrument Model Number
2. Serial Number
3. Circuit Reference Symbol
4. Description of Part

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
AT302		ATTENUATOR ASSEMBLY: 10 mc - 1 kmc. Part of RF attenuator assembly A4-11316. Replace as a unit.	BZ A4-11316	1	
AT303		ATTENUATOR ASSEMBLY: 1 - 11 kmc. Part of RF attenuator assembly A4-11316. Replace as a unit.	BZ A4-11316	1	
B101		FAN MOTOR: 4 W, CW rotation Pan Part B2065	DA AM4014J	1	
B303		MOTOR ACTUATOR: 115 vac, 60 or 400 cps Pan Part B2092	BZ B2092	1	
C101		CAPACITOR: fixed, paper, rectangular, oil-filled, 4 uf, ±10%, 2 KV Pan Part CP70E1FJ405K-10	CA CP70E1FJ405K	2	
C103		CAPACITOR: fixed, paper, rectangular, oil-filled, 4 uf, ±10%, 2 KV DCW Pan Part CP70E1FJ405K-10	CA CP70E1FJ405K		
C105		CAPACITOR: fixed, ceramic, plate type, .1 uf, 600 WVDC Pan Part CC2168-14	AS DF-104	4	
C107		CAPACITOR: fixed, paper, rectangular, oil-filled, .25 uf, ±10%, 3 KV DCW Pan Part CP70E1DL254K-10	CA CP70E1DL254K	4	
C109		CAPACITOR: fixed, paper, rectangular, oil-filled, .25 uf, ±10%, 3 KV DCW Pan Part CP70E1DL254K-10	CA CP70E1DL254K		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
C111		CAPACITOR: fixed, paper, rectangular, oil-filled, .25 uf, $\pm 10\%$, 3 KV DCW Pan Part CP70E1DL254K-10	CA CP70E1DL254K		
C113		CAPACITOR: fixed, paper, rectangular, oil-filled, .25 uf, $\pm 10\%$, 3 KV DCW Pan Part CP70E1DL254K-10	CA CP70E1DL254K		
C121 A,B		CAPACITOR: electrolytic, plug-in type, 2 x 20 uf, 450 WVDC Pan Part CE52D200R-1	CD CE52D200R	2	
C123		CAPACITOR: fixed, ceramic disc, .05 uf, $+80\%$, -20% , 500 WVDC Pan Part CC2123-13	CD 41C105	8	
C125		CAPACITOR: fixed, ceramic disc .05 uf, $+80\%$, -20% , 500 WVDC Pan Part CC2123-13	CD 41C105		
C127 A,B		CAPACITOR: electrolytic, plug-in type, 2 x 30 uf, 450 WVDC Pan Part CE52F300R-1	CD CE52F300R	1	
C129 A,B		CAPACITOR: electrolytic, plug-in type, 2 x 20 uf, 450 WVDC Pan Part CE52D200R-1	CD CE52D200R		
C131		CAPACITOR: fixed, silvered mica, 5100 uuf, $\pm 5\%$ Pan Part CM35C512J	BC CM35C512J	1	
C132*		CAPACITOR: fixed, silvered mica, 100 uuf, $\pm 5\%$ Pan Part CM20C101J	BC CM20C101J	1	
C133		CAPACITOR: fixed, ceramic, plate type, .1 uf, 600 WVDC Pan Part CC2168-14	AS DF-104		
C134		CAPACITOR: fixed, ceramic disc, .01 uf, GMV, 500 WVDC Pan Part CC2003-2	DC CD-16XD-103Z	25	
C135 A,B,C		CAPACITOR: electrolytic, plug-in type, 3 x 20 uf, 450 WVDC Pan Part CE53D200R-1	CD CE53D200R	1	
C136		CAPACITOR: fixed, ceramic disc, .01 uf, GMV, 500 WVDC Pan Part CC2003-2	DC CD-16XD-103Z		

* For serial number 169 and above.

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
C139		CAPACITOR: electrolytic, energy storage type, 2000 uf, 50 WVDC Pan Part CE2135-10	CA DCM, 2M/50	1	
C141		CAPACITOR: fixed, ceramic, plate type, .1 uf, 600 WVDC Pan Part CC2168-14	AS DF-104		
C143		CAPACITOR: fixed, ceramic, plate type, .1 uf, 600 WVDC Pan Part CC2168-14	AS DF-104		
C145		CAPACITOR: fixed, ceramic disc, .01 uf, GMV, 500 WVDC Pan Part CC2003-2	DC CD-16XD-103Z		
C147		CAPACITOR: fixed, silvered mica, 1000 uuf, $\pm 5\%$ Pan Part CM20C102J	BC CM20C102J	2	
C149		CAPACITOR: fixed, silver mica 1000 uuf, $\pm 5\%$ Pan Part CM20C102J	BC CM20C102J		
C151		CAPACITOR: fixed, ceramic disc type, .005 uf, $\pm 20\%$, 3000 WVDC Pan Part CC2137-14	AS DD30-502	4	
C153		CAPACITOR: fixed, ceramic disc type, .005 uf, $\pm 20\%$, 3000 WVDC Pan Part CC2137-14	AS DD30-502		
C301		CAPACITOR: fixed, silver mica button type, hermetically sealed feed thru type, 7/16" - 20 UNEF-2A threaded stud mounting, 500 WVDC at 125° C 500 uuf, $\pm 20\%$ Pan Part CMB2145-13	BD 2892	2	
C303		CAPACITOR: fixed, silver mica, button type, hermetically sealed feed-thru type, 7/16" - 20 UNEF-2A threaded stud mounting, 500 WVDC at 125°C, 500 uuf, $\pm 20\%$ Pan Part CMB2145-13	BD 2892		
C305		CAPACITOR: fixed, silver mica, button type, 3 solder lug mounting tabs, eyelet terminal 500 uuf, $\pm 20\%$ Pan Part CMB2146-13	BD 370-CH-501M	2	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
C307		CAPACITOR: fixed, silver mica button type, 3 solder lug mounting tabs, eyelet terminal 500 uuf, $\pm 20\%$ Pan Part CMB2146-13	BD 370-CH-501M		
C309		CAPACITOR: variable, piston type trimmer, pigtail retainer .8 - 4.5 uuf Pan Part CV2199-21	BR VC10GW	2	
C310		CAPACITOR: variable, piston type trimmer, mounting lug retainer, .8-4.5 uuf Pan Part CV2198-21	BR VC10G	1	
C311		CAPACITOR: variable, piston type, trimmer, mounting lug retainer, .8 uuf to 4.5 uuf Pan Part CV2199-21	BR VC10GW		
C313		CAPACITOR: fixed, silver mica, button type, 3 solder lug mounting tabs, single L-type terminals, 15 uuf, ± 2 uuf Pan Part CMB2141-13	BD 370CA150 ± 2 uuf	1	
C315		CAPACITOR: fixed, ceramic, feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S	39	
C317		CAPACITOR: fixed, composition axial wire leads, 1 uuf, $\pm 5\%$ Pan Part CC2143-15	CF GA	4	
C319		CAPACITOR: fixed, ceramic, feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		
C320		CAPACITOR: fixed, electrolytic twistlock, 4000 uf, 15 WVDC Pan Part CE31X402E-1	CE TVL-1173	2	
C321		CAPACITOR: fixed, silvered mica, button type, 3-48 tapped base hole, single U-type ter- minal, 1000 uuf, $\pm 10\%$ Pan Part CMB2142-13	BD 370FC102K	11	
C322		CAPACITOR: fixed, electrolytic twistlock, 4000 uf, 15 WVDC Pan Part CE31X402E-1	CE TVL-1173		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
C323		CAPACITOR: fixed, paper, H.V. glass cased, .1 uf, $\pm 10\%$, 2500 WVDC Pan Part CT2156-5	BH GC245K104K	2	
C325		CAPACITOR: fixed, paper, H.V. glass cased, .1 uf, $\pm 10\%$, 2500 WVDC Pan Part CT2156-5	BH GC245K104K		
C327		CAPACITOR: fixed, mylar, flat tubular, .47 uf, $\pm 20\%$, 400 WVDC Pan Part CT2128-5	BH 338E474M	1	
C329		CAPACITOR: variable, piston type, .8 - 4.5 uuf Pan Part CV2253	BR VC21G		
C331		CAPACITOR: fixed, dura-mica 22 uuf, $\pm 5\%$ Pan Part DM15E220J	BC DM 15E220J		
C333		CAPACITOR: fixed, dura-mica 24 uuf, $\pm 5\%$ Pan Part DM 15E 240J	BC DM 15E240J		
C335		CAPACITOR: fixed, dura-mica 15 uuf, $\pm 5\%$ Pan Part DM 15E 150J	BC DM 15E150J		
C401		CAPACITOR: fixed, dura-mica 150 uuf, $\pm 5\%$ Pan Part DM 15E151J	BC DM 15E151J	3	
C403		CAPACITOR: fixed, feed-thru, ceramic, 1000 uuf, $\pm 20\%$, 500 WVDC Pan Part CC2278-13	BD X5S		
C405		CAPACITOR: fixed, feed-thru, ceramic, 1000 uuf, $\pm 20\%$, 500 WVDC Pan Part CC2278-13	BD X5S		
C407		CAPACITOR: variable, minia- ture, piston type trimmer 1-12 uuf, 1000 WVDC Pan Part CV2217-21	BR VC22G	5	
C409		CAPACITOR: fixed, feed-thru ceramic, 1000 uuf, $\pm 20\%$, 500 WVDC Pan Part CC2278-13	BD X5S		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
C411		CAPACITOR: variable, minia- ture, piston type trimmer, 1 - 12 uuf, 1000 WVDC Pan Part CV2217-21	BR VC22G		
C413		CAPACITOR: fixed, dura-mica 10 uuf, $\pm 5\%$ Pan Part DM 15E 100J	BC DM 15E100J	2	
C415		CAPACITOR: variable, minia- ture piston type trimmer, 1 - 12 uuf, 1000 WVDC Pan Part CV2217-21	BR VC22G		
C417		CAPACITOR: fixed, dura-mica 150 uuf, $\pm 5\%$ Pan Part DM15E151J	BC DM15E151J		
C419		CAPACITOR: fixed, feed-thru, ceramic, 1000 uuf, $\pm 20\%$, 500 WVDC Pan Part CC2278-13	BD X5S		
C421		CAPACITOR: fixed, feed-thru, ceramic, 1000 uuf, $\pm 20\%$, 500 WVDC Pan Part CC278-13	BD X5S		
C423		CAPACITOR: variable, minia- ture, piston type trimmer 1 - 12 uuf, 1000 WVDC Pan Part CV2217-21	BR VC22G		
C425		CAPACITOR: fixed, dura-mica, 10 uuf, $\pm 5\%$ Pan Part DM 15E 100J	BC DM 15E100J		
C427		CAPACITOR: fixed, dura-mica, 150 uuf, $\pm 5\%$ Pan Part DM15E151J	BC DM15E151J		
C429		CAPACITOR: variable, minia- ture piston type trimmer 1 - 12 uuf, 1000 WVDC Pan Part CV2217-21	BR VC22G		
C431		CAPACITOR: fixed, feed-thru, 1000 uuf, $\pm 20\%$, 500 WVDC Pan Part CC2278-13	BD X5S		
C434		CAPACITOR: fixed, feed-thru 1000 uuf, $\pm 20\%$, 500 WVDC Pan Part CC2278-13	BD X5S		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
C435		CAPACITOR: fixed, feed-thru 1000 uuf, $\pm 20\%$, 500 WVDC Pan Part CC2278-13	BD X5S		
C462		CAPACITOR: fixed, silvered mica, 47 uuf, $\pm 5\%$ Pan Part CM 15 470J	BC CM15470J	9	
C463		CAPACITOR: fixed, silvered mica, 47 uuf, $\pm 5\%$ Pan Part CM 15 470J	BC CM15470J		
C464		CAPACITOR: variable, minia- ture, air, single section, 2.7 - 19.6 uuf Pan Part CV2091	BS 160-110		
C466		CAPACITOR: fixed, composition 1 uuf, $\pm 5\%$, axial wire leads Pan Part CC2143-15	CF GA		
C467		CAPACITOR: fixed, silvered mica, 22 uuf, $\pm 5\%$ Pan Part CM15-220J	BC CM15-220J		
C468		CAPACITOR: fixed, composition 1 uuf, $\pm 5\%$, axial wire leads Pan Part CC2143-15	CF GA		
C469		CAPACITOR: fixed, silvered mica, 12 uuf, $\pm 5\%$ Pan Part CM15-120J	BC CM15-120J		
C470		CAPACITOR: fixed, composition, 5.1 uuf, $\pm 5\%$ Pan Part CC2157-15	CF GA		
C491		CAPACITOR: fixed, silvered mica, 150 uuf, $\pm 5\%$ Pan Part CM15-151J	BC CM15-151J		
C497		CAPACITOR: variable, piston type, 1 - 18 uuf Pan Part CV2062	BR VC4G	5	
C499		CAPACITOR: fixed, ceramic, feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		
C503		CAPACITOR: fixed, ceramic, feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
C504		CAPACITOR: fixed, silvered mica, 5 uuf, $\pm 5\%$ Pan Part CM15-050J	BC CM15-050J	2	
C505		CAPACITOR: fixed, ceramic, feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		
C507		CAPACITOR: variable, piston type, 1 - 18 uuf Pan Part CV2062	BR VC4G		
C509		CAPACITOR: variable, piston type, 1 - 18 uuf Pan Part CV2062	BR VC4G		
C511		CAPACITOR: fixed, silvered mica, 150 uuf, $\pm 5\%$ Pan Part CM15-150J	BC CM15-150J	3	
C513		CAPACITOR: fixed, ceramic, feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		
C515		CAPACITOR: fixed, ceramic, feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		
C517		CAPACITOR: fixed, ceramic feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		
C519		CAPACITOR: variable, piston type, 1 - 18 uuf Pan Part CV2062	BR VC4G		
C520		CAPACITOR: fixed, silvered mica, 5 uuf, $\pm 5\%$ Pan Part CM15-050J	BC CM15-050J		
C521		CAPACITOR: fixed, silvered mica, 150 uuf, $\pm 5\%$ Pan Part CM15-150J	BC CM15-150J		
C523		CAPACITOR: variable, piston type, 1 - 18 uuf Pan Part CV2062	BR VC4G		
C596		CAPACITOR: fixed, ceramic feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
C597		CAPACITOR: fixed, ceramic feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S	74	
C600		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C601		CAPACITOR: fixed, ceramic feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		
C602		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C603		CAPACITOR: fixed, ceramic disc, .01 uf, GMV, 500 WVDC Pan Part CC2003-2	DC CD-16XD103Z		
C604		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C605		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C606		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A	9	
C607		CAPACITOR: fixed, ceramic feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		
C608		CAPACITOR: fixed, silvered mica, 47 uuf, $\pm 5\%$ Pan Part CM15C470J	BC CM15C470J		
C609		CAPACITOR: fixed, ceramic feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		
C610		CAPACITOR: fixed, ceramic feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		
C611		CAPACITOR: fixed, ceramic disc, .01 uf, GMV, 500 WVDC Pan Part CC2003-2	DC CD-16XD103Z		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
C612		CAPACITOR: fixed, ceramic disc, .01 uf, GMV, 500 WVDC Pan Part CC2003-2	DC CD-16XD103Z		
C614		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C615		CAPACITOR: fixed, ceramic disc, .01 uf, GMV, 500 WVDC Pan Part CC2003-2	DC CD-16XD103Z		
C618		CAPACITOR: variable, trimmer ceramic, button type, 7-35 uuf Pan Part CV2110-14	AS 827D	1	
C623		CAPACITOR: fixed, ceramic insulated, 100 uuf, $\pm 10\%$, 600 WVDC Pan Part CC1088a-14	AS D6-101	1	
C625		CAPACITOR: fixed, ceramic disc, .01 uf, GMV, 500 WVDC Pan Part CC2003-2	DC CD-16XD103Z		
C627		CAPACITOR: fixed, silvered mica, button type, 3-48 tapped basehole, single U type ter- minal, 1000 uuf, $\pm 10\%$ Pan Part CMB2142-13	BD 370FC102K		
C628		CAPACITOR: fixed, ceramic disc, .01 uf, GMV, 500 WVDC Pan Part CC2003-2	DC CD-16XD103Z		
C629		CAPACITOR: fixed, ceramic feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		
C631		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C633		CAPACITOR: fixed, ceramic disc, .02 uf, $\pm 20\%$, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C639		CAPACITOR: fixed, ceramic disc, .01 uf, GMV, 500 WVDC Pan Part CC2003-2	DC CD-16XD103Z		
C641		CAPACITOR: fixed, ceramic, disc, .01 uf, GMV, 500 WVDC Pan Part CC2003-2	DC CD-16XD103Z		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
C703		CAPACITOR: variable, air, duel 4.8 uuf to 27.3 uuf/section Pan Part CV2139	BJ BFC-25	1	
C704		CAPACITOR: variable, piston type, ceramic, 0.6 - 6 uuf Pan Part CV2051	BR VC-5	1	
C705		CAPACITOR: variable, butterfly 1.8 uuf to 5.1 uuf Pan Part CV2203	BS 160-205	1	
C707		CAPACITOR: fixed, composition, axial wire leads, 4.7 uuf, $\pm 5\%$ Pan Part CC2031-15	CF GA-4.7-5%	2	
C709		CAPACITOR: fixed, composition, axial wire leads, 4.7 uuf, $\pm 5\%$ Pan Part CC2031-15	CF GA-4.7-5%		
C713		CAPACITOR: fixed, ceramic disc type, .001 uf, $\pm 20\%$ 1000 WVDC Pan Part CC2152-14	AS DD-102	8	
C715		CAPACITOR: fixed, ceramic disc type, .001 uf, $\pm 20\%$, 1000 WVDC Pan Part CC2152-14	AS DD-102		
C717		CAPACITOR: fixed, ceramic feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		
C719		CAPACITOR: fixed, ceramic feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		
C720		CAPACITOR: fixed, ceramic feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		
C721		CAPACITOR: fixed, ceramic feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		
C723		CAPACITOR: fixed, ceramic disc, .01 uf, GMV, 500 WVDC Pan Part CC2003-2	DC CD-16XD103Z		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
C725		CAPACITOR: fixed, ceramic disc type, .001 uf, $\pm 20\%$, 1000 WVDC Pan Part CC2152-14	AS DD-102		
C727		CAPACITOR: fixed, ceramic feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		
C729		CAPACITOR: fixed, ceramic disc, .01 uf, GMV, 500 WVDC Pan Part CC2003-2	DC CD-16XD103Z		
C801		CAPACITOR: fixed, silvered mica, button type, 3-48 tapped basehole, single U type ter- minal, 1000 uuf, $\pm 10\%$ Pan Part CMB2142-13	BD 370FC102K		
C803		CAPACITOR: fixed, silvered mica, button type, 3-48 tapped basehole, long L type terminal 1000 uuf, $\pm 10\%$ Pan Part CMB2148-13	BD 370FF102K	6	
C805		CAPACITOR: fixed, silvered mica, button type, 3-48 tapped basehole, long L type terminal 1000 uuf, $\pm 10\%$ Pan Part CMB2148-13	BD 370FF102K		
C806		CAPACITOR: fixed, ceramic disc, .01 uf, GMV, 500 WVDC Pan Part CC2003-2	DC CD-16XD103Z		
C807		CAPACITOR: fixed, silvered mica, button type, 3-48 tapped basehole, single U type ter- minal, 1000 uuf, $\pm 10\%$ Pan Part CMB2142-13	BD 370FC102K		
C809		CAPACITOR: fixed, silver mica 47 uuf, $\pm 5\%$ Pan Part CMB2148-13	BC CM15C470J		
C811		CAPACITOR: fixed, silvered mica, button type, 3-48 tapped basehole, single U type ter- minal, 1000 uuf, $\pm 10\%$ Pan Part CMB2142-13	BD 370FC102K		
C813		CAPACITOR: fixed, ceramic disc, .01 uf, GMV, 500 WVDC Pan Part CC2003-2	DC CD-16XD103Z		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
C815		CAPACITOR: fixed, ceramic, feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		
C817		CAPACITOR: fixed, silver mica button type, 3-48 tapped base- hole, long L type terminal 1000 uuf, $\pm 10\%$ Pan Part CMB2148-13	BD 370FF102K		
C819		CAPACITOR: fixed, silvered mica, button type, 3-48 tapped basehole, long L type terminal 1000 uuf, $\pm 10\%$ Pan Part CMB2148-13	BD 370FF102K		
C821		CAPACITOR: fixed, silvered mica, button type, 3-48 tapped basehole, single U type ter- minal, 1000 uuf, $\pm 10\%$ Pan Part CMB2142-13	BD 370FC102K		
C823		CAPACITOR: fixed, silvered mica, 47 uuf, $\pm 5\%$ Pan Part CM15C470J	BC CM15C470J		
C825		CAPACITOR: fixed, silvered mica, button type, 3-48 tapped basehole, single U type ter- minal, 1000 uuf, $\pm 10\%$ Pan Part CMB2142-13	BD 370FC102K		
C827		CAPACITOR: fixed, silver mica button type, 3-48 tapped base- hole, long L type terminal 1000 uuf, $\pm 10\%$ Pan Part CMB2148-13	BD 370 FF102K		
C829		CAPACITOR: fixed, silver mica button type, 3-48 tapped base- hole, long L type terminal 1000 uuf, $\pm 10\%$ Pan Part CMB2148-13	BD 370FF102K		
C831		CAPACITOR: fixed, silvered mica, button type, 3-48 tapped basehole, single U type ter- minal, 1000 uuf, $\pm 10\%$ Pan Part CMB2142-13	BD 370FC102K		
C833		CAPACITOR: fixed, silvered mica, 24 uuf, $\pm 5\%$ Pan Part CM15C240J	BC CM15C240J	1	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
C835		CAPACITOR: fixed, composition axial wire leads, 1 uuf, $\pm 5\%$ Pan Part CC2143-15	CF GA-1.0-5%		
C837		CAPACITOR: fixed, ceramic disc, .01 uf, GMV, 500 WVDC Pan Part CC2003-2	DC CD-16XD103Z		
C839		CAPACITOR: fixed, silvered mica, 47 uuf, $\pm 5\%$ Pan Part CM15C470J	BC CM15C470J		
C841		CAPACITOR: fixed, ceramic disc, .01 uf, GMV, 500 WVDC Pan Part CC2003-2	DC CD-16XD103Z		
C843		CAPACITOR: fixed, silvered mica, 47 uuf, $\pm 5\%$ Pan Part CM15C470J	BC CM15C470J		
C845		CAPACITOR: fixed, ceramic disc, .01 uf, GMV, 500 WVDC Pan Part CC2003-2	DC CD-16XD103Z		
C847		CAPACITOR: fixed, ceramic feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		
C849		CAPACITOR: fixed, silvered mica, 47 uuf, $\pm 5\%$ Pan Part CM15C470J	BC CM15C470J		
C851		CAPACITOR: fixed, ceramic feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		
C853		CAPACITOR: fixed, ceramic feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		
C855		CAPACITOR: fixed, silvered mica, button type, 3-48 tapped basehole, single U type ter- minal, 1000 uuf, $\pm 10\%$ Pan Part CMB2142-13	BD 370FC102K		
C857		CAPACITOR: fixed, silvered mica, button type, 3-48 tapped basehole, single U type ter- minal, 1000 uuf, $\pm 10\%$ Pan Part CMB2142-13	BD 370FC102K		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
C 859		CAPACITOR: fixed, silvered mica, button type, 3-48 tapped basehole, single U type terminal, 1000 uuf, $\pm 10\%$ Pan Part CMB2142-13	BD 370FC102K		
C 861		CAPACITOR: fixed, ceramic feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		
C 863		CAPACITOR: fixed, ceramic disc, .01 uf, GMV, 500 WVDC Pan Part CC2003-2	DC CD-16XD103Z		
C 865		CAPACITOR: fixed, ceramic feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		
C 867		CAPACITOR: fixed, ceramic disc, .01 uf, GMV, 500 WVDC Pan Part CC2003-2	DC CD-16XD103Z		
C 869		CAPACITOR: fixed, ceramic feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		
C1001		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1003		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1005		CAPACITOR: fixed, silvered mica, 510 uuf, $\pm 5\%$ Pan Part CM15C511J	BC CM15C511J	5	
C1007		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1009		CAPACITOR: fixed, ceramic feed-thru type, 1000 uuf, $\pm 20\%$, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		
C1015		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1017		CAPACITOR: fixed, silvered mica, 510 uuf, $\pm 5\%$ Pan Part CM15C511J	BC CM15C511J		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
C1019		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1021		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1023		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1025		CAPACITOR: fixed, silvered mica, 510 uuf, $\pm 5\%$ Pan Part CM15C511J	BC CM15C511J		
C1027		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1029		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1031		CAPACITOR: fixed, ceramic disc, .01 uf, GMV, 500 WVDC Pan Part CC2003-2	DC CD-16XD103Z		
C1033		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1035		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1037		CAPACITOR: fixed, silvered mica, 510 uuf, $\pm 5\%$ Pan Part CM15C511J	BC CM15C511J		
C1038		CAPACITOR: fixed, composition, axial leads, 1.5 uuf, $\pm 5\%$ Pan Part CC2144-15	CF GA		
C1039		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1040		CAPACITOR: fixed, silvered mica, 12 uuf, $\pm 5\%$ Pan Part CM15-120J	BC CM15-120J		
C1041		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
C1043		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1045		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1047		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1049		CAPACITOR: fixed, ceramic feed-thru type, 1000 uuf, ±20%, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		
C1050		CAPACITOR: fixed, composition, 10 uuf, ±5% Pan Part CC2159-15	CF GA		
C1051		CAPACITOR: fixed, silvered mica, 47 uuf, ±5% Pan Part CM15C470J	BC CM15C470J		
C1052		CAPACITOR: fixed, composition .68 uuf, ±20% Pan Part CC2006-15	CF GA-.68-20%		
C1053		CAPACITOR: fixed, silvered mica, 470 uuf, ±5% Pan Part CM15C471J	BC CM15C471J	2	
C1055		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1057		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1059		CAPACITOR: fixed, silvered mica, 470 uuf, ±5% Pan Part CM15C471J	BC CM15C471J		
C1061		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1063		CAPACITOR: fixed, dry electro- lytic, axial wire lead, card- board jacket, 20 uf, 450 WVDC Pan Part CE71X200R-1	CE TVA-1709	1	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
C1065		CAPACITOR: fixed, ceramic disc, .05 uf, +80%, -20%, 500 WVDC Pan Part CC2123-13	CD 41C105		
C1067		CAPACITOR: fixed, ceramic disc, .05 uf, +80%, -20%, 500 WVDC Pan Part CC2123-13	CD 41C105		
C1069		CAPACITOR: fixed, ceramic disc, .001 uf, ±20%, 1000 WVDC Pan Part CC2152-14	AS DD-102		
C1071		CAPACITOR: fixed, ceramic disc, .05 uf, +80%, -20%, 500 WVDC Pan Part CC2123-13	CD 41C105		
C1073		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1075		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1077		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1079		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1081		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1082		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1083		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1085		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1087		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
C1089		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1091		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1092		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1093		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1094		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1095		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1096		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1097		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1098		CAPACITOR: fixed, ceramic feed-thru type, 1000 uuf, ±20%, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		
C1099		CAPACITOR: fixed, ceramic feed-thru type, 1000 uuf, ±20%, NPO, 500 WVDC Pan Part CC2278-13	BD X5S		
C1101		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1103		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1107		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
C1111		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1113		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1115		CAPACITOR: fixed, ceramic disc type, .001 uf, $\pm 20\%$, 1000 WVDC Pan Part CC2152-14	AS DD-102		
C1117		CAPACITOR: fixed, ceramic disc type, .001 uf, $\pm 20\%$, 1000 WVDC Pan Part CC2152-14	AS DD-102		
C1119		CAPACITOR: variable, silvered ceramic, trimmer type, 3-12 uuf, NPO, 500 WVDC Pan Part CV2111-13	BD 557-B	2	
C1121		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1123		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1125		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1127		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1129		CAPACITOR: fixed, ceramic disc type, .001 uf, $\pm 20\%$, 1000 WVDC Pan Part CC2152-14	AS DD-102		
C1131		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1133		CAPACITOR: fixed, ceramic disc type, .001 uf, $\pm 20\%$, 1000 WVDC Pan Part CC2152-14	AS DD-102		
C1135		CAPACITOR: variable, silvered ceramic, trimmer type, 3-12 uuf, NPO, 500 WVDC Pan Part CV2111-13	BD 557-B		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
C1137		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1139		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1141		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1143		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1145		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1147		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1148		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1149		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1151		CAPACITOR: fixed, silvered mica, 56 uuf, $\pm 5\%$ Pan Part CM15C560J	BC CM15C560J	2	
C1155		CAPACITOR: fixed, silvered mica, 56 uuf, $\pm 5\%$ Pan Part CM15C560J	BC CM15C560J		
C1157		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1159		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1161		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1163		CAPACITOR: fixed, ceramic disc .05 uf, $+80\%$, -20% , 500 WVDC Pan Part CC2123-13	CD 41C105		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
C1165		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1167		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1169		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1171		CAPACITOR: fixed, ceramic disc, .05 uf, +80%, -20%, 500 WVDC Pan Part CC2123-13	CD 41C105		
C1201		CAPACITOR: fixed, flat, tubular, mylar, extended foil con- struction, .047 uf, ±20%, 400 WVDC Pan Part CT2124-5	BH 338E473M	1	
C1203		CAPACITOR: fixed, flat, tubular mylar, extended foil construc- tion, .0047 uf, ±20%, 400 WVDC Pan Part CT2132-5	BH 338E472M	2	
C1205		CAPACITOR: fixed, silvered mica, 20 uuf, ±5% Pan Part CM15C200J	BC CM15C200J	1	
C1207		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1208		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1209		CAPACITOR: fixed, silvered mica, 510 uuf, ±5% Pan Part CM15C511J	BC CM15C511J		
C1210		CAPACITOR: fixed, ceramic disc, .02 uf, GMV, 500 WVDC Pan Part CC2055-1	CD 29C187A		
C1301		CAPACITOR: fixed, ceramic disc, .01 uf, GMV, 500 WVDC Pan Part CC2003-2	DC CD-16XD103Z		
C1303		CAPACITOR: fixed, ceramic disc, .01 uf, GMV, 500 WVDC Pan Part CC2003-2	DC CD-16XD103Z		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
C1305		CAPACITOR: fixed, flat tubular mylar, extended foil construc- tion, .0047 uf, $\pm 20\%$, 400 WVDC Pan Part CT2132-5	BH 338E472M		
C1307		CAPACITOR: fixed, ceramic disc, .01 uf, GMV, 500 WVDC Pan Part CC2003-2	DC CD-16XD103Z		
C1309		CAPACITOR: fixed, flat tubular, mylar, extended foil construc- tion, .022 uf, $\pm 20\%$, 150 WVDC Pan Part CT2150-5	BH 338Y223M	1	
C1311		CAPACITOR: fixed, silvered mica, 91 uuf, $\pm 5\%$ Pan Part CM15C910J	BC CM15C910J	1	
C1313		CAPACITOR: fixed, paper, oil- filled, bathtub, side mounted terminals, 4 uf, $\pm 20\%$, 400 WVDC Pan Part CP50B1XE405M-3	AB P30Z aerolite	1	
C1401		CAPACITOR: fixed, ceramic, disc type, .005 uf, $\pm 20\%$, 3000 WVDC Pan Part CC2137-14	AS DD30-502		
C1403		CAPACITOR: fixed, ceramic disc type, .005 uf, $\pm 20\%$, 3000 WVDC Pan Part CC2137-14	AS DD30-502		
C1405		CAPACITOR: fixed, ceramic disc, .05 uf, $+80\%$, -20% , 500 WVDC Pan Part CC2123-13	CD 41C105		
CP101		PLUG: adaptor Pan Part W3033-2	AW 228	1	
CP301		CONNECTOR: straight adaptor series N, Mil Type UG-57B/U Pan Part P2089	AJ 82-100	2	
CP302		CONNECTOR: RF type N "tee" 3 female ends Pan Part P2119	AJ 82-99	1	
CP303		CONNECTOR: straight adaptor series N, Mil Type UG-57B/U Pan Part P2089	AJ 82-100		
CP304		CONNECTOR: receptacle, RF Mil. No. UG-29A/U modified Pan Part J2087	CZ KN-99-14	1	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
CP701		CONNECTOR: "tee" adaptor Pan Part P2120 (serial nos. 151-300)	CC 3044	1	
CP701		CONNECTOR: "tee" adaptor Pan Part P2156 (serial nos. 301 and up)	CC 3144	1	
CP703		CONNECTOR: adaptor, RF conhex to BNC Pan Part J2086 (for serial nos. 151-300)	CC 5131	6	
CP703		CONNECTOR: adaptor, RF 75 ohm, snap-on series, conhex to BNC Pan Part J3013 (for serial nos. 301-350)	CC 31431-P80	6	
CP1001		CONNECTOR: adaptor, RF conhex to BNC Pan Part J2086 (for serial nos. 151-300)	CC 5131		
CP1001		CONNECTOR: adaptor, RF 75 ohm, snap-on series, conhex to BNC Pan Part J3013 (for serial nos. 301-350)	CC 31431-P80		
CP1203		CONNECTOR: adaptor, RF conhex to BNC Pan Part J2086 (For serial nos. 151-300)	CC 5131		
CP1203		CONNECTOR: adaptor, RF 75 ohm, snap-on series, conhex to BNC Pan Part J3013 (for serial nos. 301-350)	CC 31431-P80		
CP1205		CONNECTOR: adaptor, RF conhex to BNC Pan Part J2086 (for serial nos 151-300)	CC 5131		
CP1205		CONNECTOR: adaptor, RF 75 ohm, snap-on series, conhex to BNC Pan Part J3013 (for serial nos 301-350)	CC 31431-P80		
CP1301		CONNECTOR: adaptor, RF conhex to BNC Pan Part J2086 (for serial nos. 151-300)	CC 5131		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
CP1301		CONNECTOR: adaptor, RF 75 ohm, snap-on series conhex to BNC Pan Part J3013 (for serial nos. 301-350)	CC 31431-P80		
CP1311		CONNECTOR: adaptor, RF conhex to BNC Pan Part J2086 (for serial nos. 151-300)	CC 5131		
CP1311		CONNECTOR: adaptor, RF 75 ohm, snap-on series conhex to BNC Pan Part J3013 (for serial nos. 301-350)	CC 31431-P80		
CR101 A,B,C,D		Diode, silicon, JETEC#1N1084 Pan Part CR-1N1084	CB M500	12	
CR103 A,B,C,D		DIODE: silicon, JETEC#1N1084 Pan Part CR-1N1084	CB M500		
CR105 A,B,C,D		DIODE: silicon, JETEC #1N1084 Pan Part CR-1N1084	CB M500		
CR107		DIODE: silicon, JETEC #1N1450 Pan Part CR-1N1450	AN 10-F1	2	
CR109		DIODE: silicon, JETEC #1N1450 Pan Part CR-1N1450	AN 10-F1		
CR111		DIODE: silicon, zener, JETEC #1N1605 Pan Part CR-1N1605	BP 10Z12	2	
CR115		DIODE: silicon, zener, JETEC #1N1605 Pan Part CR-1N1605	BP 10Z12		
CR301		DIODE: silicon, 1N1089 Pan Part CR-1N1089	CB 10LF	4	
CR303		DIODE: silicon, 1N1089 Pan Part CR-1N1089	CB 10LF		
CR305		DIODE: zener, 10 W, 6.3 V nominal Pan Part CR-2015	BP 10Z6.3	2	
CR307		DIODE: silicon, 1N1089 Pan Part CR-1N1089	CB 10LF		
CR309		DIODE: silicon, 1N1089 Pan Part CR-1N1089	CB 10LF		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
CR311		DIODE: zener, 10 W 6.3 V nominal Pan Part CR-2015	BP 10Z6.3		
CR313		DIODE: microwave, silicon type 1N358A Pan Part CR-1N358A	CH 1N358A	1	
CR315		DIODE: microwave, silicon type 1N26 Pan Part CR-JAN-1N26	CH 1N26	1	
CR317		DIODE: microwave, silicon type 1N78 Pan Part CR-JAN-1N78	CH 1N78	1	
CR319		DIODE: microwave, silicon type 1N53 Pan Part CR-JAN-1N53	CH 1N53	1	
DS300		LAMP: neon, amber, NE-2H bulb, 33K series resistor, with legend "on" imprinted Pan Part B2093	BA 249-7841H-1433	2	
DS301		LAMP: pilot, 1-1-3/4 bulb, midget flanged base, 6 V, .2 A Pan Part B2055	AL 328	21	
DS303		LAMP: pilot, 1-1-3/4 bulb, midget flanged base, 6 V, .2 A Pan Part B2055	AL 328		
DS305		LAMP: pilot, 1-1-3/4 bulb, midget flanged base, 6 V, .2 A Pan Part B2055	AL 328		
DS307		LAMP: pilot, 1-1-3/4 bulb, midget flanged base, 6 V, .2 A Pan Part B2055	AL 328		
DS309		LAMP: pilot, 1-1-3/4 bulb, midget flanged base, 6 V, .2 A Pan Part B2055	AL 328		
DS311		LAMP: pilot, T-1-3/4 bulb, midget flanged base, 6 V, .2 A Pan Part B2055	AL 328		
DS313		LAMP: pilot, T-1-3/4 bulb, midget flanged base, 6 V, .2 A Pan Part B2055	AL 328		
DS315		LAMP: pilot, T-1-3/4 bulb, midget flanged base, 6 V, .2 A Pan Part B2055	AL 328		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
DS317		LAMP: pilot, T-1-3/4 bulb, midget flanged base, 6 V, .2 A Pan Part B2055	AL 328		
DS319		LAMP: pilot, T-1-3/4 bulb, midget flanged base, 6 V, .2 A Pan Part B2055	AL 328		
DS321		LAMP: pilot, T-1-3/4 bulb, midget flanged base, 6 V, .2 A Pan Part B2055	AL 328		
DS323		LAMP: pilot, T-1-3/4 bulb, midget flanged base, 6 V, .2 A Pan Part B2055	AL 328		
DS325		LAMP: pilot, T-1-3/4 bulb, midget flanged base, 6 V, .2 A Pan Part B2055	AL 328		
DS327		LAMP: pilot, T-1-3/4 bulb, midget flanged base, 6 V, .2 A Pan Part B2055	AL 328		
DS329		LAMP: pilot, T-1-3/4 bulb, midget flanged base, 6 V, .2 A Pan Part B2055	AL 328		
DS331		LAMP: pilot, T-1-3/4 bulb, midget flanged base, 6 V, .2 A Pan Part B2055	AL 328		
DS333		LAMP: pilot, T-1-3/4 bulb, midget flanged base, 6 V, .2 A Pan Part B2055	AL 328		
DS335		LAMP: neon, amber, NE-2H, bulb, 33 K series resistor with legend "on" imprinted Pan Part B2093	BA 249-7841H-1433		
DS701		LIGHT: front mounting, minia- ture, NE-2H bulb, 1 K series resistor, 1/4 watt with legend "on" imprinted on lens Pan Part B2103	CS FML-2- AFC-104	1	
DS1301		LAMP: pilot, miniature bayonet base, G-3-1/2 clear bulb, 6-8V 0.25 amps Pan Part B2042	AL 51	1	
DS1401		LAMP: pilot, miniature bayonet 6 V, .2 A, T-1-3/4 bulb Pan Part B2055	AL 328		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
DS1403		LAMP: pilot, miniature bayonet 6 V, .2 A, T-1-3/4 bulb Pan Part B2055	AL 328		
DS1405		LAMP: pilot, miniature bayonet 6 V, .2 A, T-1-3/4 bulb Pan Part B2055	AL 328		
DS1407		LAMP: pilot, miniature bayonet 6 V, .2 A, T-1-3/4 bulb Pan Part B2055	AL 328		
E1301		LAMP: neon, type NE-16 (modified), 67-1/2 VDC, 1/4 watt, type T-4-1/2 Pan Part B2026M	BZ B2026M	1	
F301		FUSE: ceramic cartridge, type 3 AB, medium timelag, 8 amp, 250 V, 3 spares supplied with accessory kit Pan Part F2014	BT 314008	5	
F302		FUSE: ceramic cartridge, type 3 AB, medium time lag, 8 amp, 250 V Pan Part F2014	BT 314008		
FL101		FILTER: r.f. interference (includes J101 receptacle) Pan Part FL2-12091A	BZ FL2-12091A		
FL401		FILTER: low pass Pan Part PR2-12686	BZ PR2-12686	1	
FL403		FILTER: band pass Pan Part PR2-12687	BZ PR2-12687	1	
J101		CONNECTOR: power, flush mount, 3 wire, male, twistlock (Part of filter ass'y. #FL2-12091) Pan Part J1002	BK 7486	1	
J106		CONNECTOR: power, outlet Pan Part J2094	DD #221	1	
J117		CONNECTOR: receptacle, 5 contact, female, locking clip Pan Part J2051	AJ 126-218	1	
J301		CONNECTOR: receptacle, wall mounting, small flange, 5 contact male Pan Part J2057	AR WK-5-32S	1	

List of Replaceable Parts for Model SPA -4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
J303		CONNECTOR: receptacle, wall mounting, small flange, 19 contact, male Pan Part J2058	AR SK-19-32S	1	
J304		JACK: test point, white Pan Part X2054W	CC SKT-8 (white)	4	
J305		CONNECTOR: receptacle, 14 contact, wall mounting Pan Part J2067	AR FK-B14-32S	1	
J306		JACK: test point, red Pan Part X2054R	CC SKT-8 (red)	4	
J308		SOCKET: miniature, 4 contact Pan Part X2088	AJ 78-S4S	2	
J309		JACK: test point, red Pan Part X2054R	CC SKT-8 (red)		
J311		JACK: test point, white Pan Part X2054W	CC SKT-8 (white)		
J312		SOCKET: miniature, 4 contact Pan Part X2088	AJ 78-S4S		
J313		JACK: test point, red Pan Part X2054R	CC SKT-8 (red)		
J314		CONNECTOR: receptacle, 12 pin, quick disconnect w/hood and locking guides Pan Part P2155	CN QRE, 12S-HLT Type C		
J315		JACK: test point, white Pan Part X2054W	CC SKT-8 (white)		
J317		JACK: test point, white Pan Part X2054W	CC SKT-8 (white)		
J318		CONNECTOR: receptacle, 6 pin Pan Part P2145	DH MAK-6		
J319		JACK: test point, red Pan Part X2054R	CC SKT-8 (red)		
J329		CONNECTOR: receptacle, bulkhead, series TNC Pan Part J2070	CX 8001-1		
J401		CONNECTOR: receptacle, 5 contact, male Pan Part J2056	AJ 126-216	8	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
J403		CONNECTOR: receptacle, 5 contact, male Pan Part J2056	AJ 126-216		
J405		CONNECTOR: receptacle, bulkhead series TNC Pan Part J2070	CX 8001-1		
J407		CONNECTOR: receptacle, bulk- head, 75 ohm series, straight, brass Pan Part J2078 (for serial nos. 151-300)	CC 3032	19	
J407		CONNECTOR: receptacle, RF, bulkhead, 75 ohm, snap-on series Pan Part J3012 (for serial nos. 301-350)	CC 3132	19	
J409		CONNECTOR: receptacle, bulkhead, 75 ohm series straight,brass Pan Part J2078 (for serial nos. 151-300)	CC 3032		
J409		CONNECTOR: receptacle, RF bulkhead, 75 ohm, snap-on series Pan Part J3012 (for serial nos. 301-350)	CC 3132		
J413		CONNECTOR: receptacle, bulkhead, 75 ohm series, straight,brass Pan Part J2078 (for serial nos. 151-300)	CC 3032		
J413		CONNECTOR: receptacle, RF bulkhead, 75 ohm, snap-on series Pan Part J3012 (for serial nos. 301-350)	CC 3132		
J417		CONNECTOR: receptacle, bulkhead, 75 ohm series, straight,brass Pan Part J2078 (for serial nos. 151-300)	CC 3032		
J417		CONNECTOR: receptacle, RF bulkhead, 75 ohm, snap-on series Pan Part J3012 (for serial nos. 301-350)	CC 3132		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
J419		CONNECTOR: receptacle, bulkhead, 75 ohm series, straight,brass Pan Part J2078 (for serial nos. 151-300)	CC 3032		
J419		CONNECTOR: receptacle, RF bulkhead, 75 ohm, snap-on series Pan Part J3012 (for serial nos. 301-350)	CC 3132		
J421		CONNECTOR: receptacle, bulkhead, 75 ohm series, straight,brass Pan Part J2078 (for serial nos. 151-300)	CC 3032		
J421		CONNECTOR: receptacle, RF bulkhead, 75 ohm, snap-on series Pan Part J3012 (for serial nos. 301-350)	CC 3132		
J423		CONNECTOR: receptacle, bulkhead, 75 ohm series, straight,brass Pan Part J2078 (for serial nos. 151-300)	CC 3032		
J423		CONNECTOR: receptacle, RF bulkhead, 75 ohm, snap-on series Pan Part J3012 (for serial nos. 301-350)	CC 3132		
J431		CONNECTOR: plug, 2 contact, male Pan Part J2096	CN JFA-2-S	2	
J601		CONNECTOR: receptacle, bulkhead, 75 ohm series, straight,brass Pan Part J2078 (for serial nos. 151-300)	CC 3032		
J601		CONNECTOR: receptacle, RF bulkhead, 75 ohm, snap-on series Pan Part J3012 (for serial nos. 301-350)	CC 3132		
J603		CONNECTOR: receptacle, bulkhead, 75 ohm series, straight,brass Pan Part J2078 (for serial nos. 151-300)	CC 3032		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
J603		CONNECTOR: receptacle, RF bulkhead, 75 ohm, snap-on series Pan Part J3012 (for serial nos. 301-350)	CC 3132		
J605		CONNECTOR: receptacle, 5 contact, male Pan Part J2056	AJ 126-216		
J701		CONNECTOR: receptacle, RF 75 ohm series, straight Pan Part P2112 (for serial nos. 151-300)	CC 3042	1	
J701		CONNECTOR: receptacle, RF 75 ohm series, straight Pan Part P2160 (for serial nos. 301-350)	CC 3142	1	
J703		CONNECTOR: plug, 2 contact, male Pan Part J2096	CN JFA-2-S		
J707		CONNECTOR: receptacle, bulkhead, 75 ohm series, straight,brass Pan Part J2078 (for serial nos. 151-300)	CC 3032		
J707		CONNECTOR: receptacle, RF bulkhead, 75 ohm, snap-on series Pan Part J3012 (for serial nos. 301-350)	CC 3132		
J725		CONNECTOR: receptacle, 5 contact, male Pan Part J2056	AJ 126-216		
J801		CONNECTOR: receptacle, bulkhead, 75 ohm series, straight,brass Pan Part J2078 (for serial nos. 151-300)	CC 3032		
J801		CONNECTOR: receptacle, RF bulkhead, 75 ohm, snap-on series Pan Part J3012 (for serial nos. 301-350)	CC 3132		
J803		CONNECTOR: receptacle, bulkhead, 75 ohm series, straight,brass Pan Part J2078 (for serial nos. 151-300)	CC 3032		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
J803		CONNECTOR: receptacle, RF bulkhead, 75 ohm, snap-on series Pan Part J3012 (for serial nos. 301-350)	CC 3132		
J805		CONNECTOR: receptacle, bulkhead, 75 ohm series, straight,brass Pan Part J2078 (for serial nos. 151-300)	CC 3032		
J805		CONNECTOR: receptacle, RF bulkhead, 75 ohm, snap-on series Pan Part J3012 (for serial nos. 301-350)	CC 3132		
J807		CONNECTOR: receptacle, bulkhead, 75 ohm series, straight,brass Pan Part J2078 (for serial nos. 151-300)	CC 3032		
J807		CONNECTOR: receptacle, RF bulkhead, 75 ohm, snap-on series Pan Part J3012 (for serial nos. 301-350)	CC 3132		
J809		CONNECTOR: receptacle, 5 contact, male Pan Part J2056	AJ 126-216		
J811		CONNECTOR: receptacle, 5 contact, male Pan Part J2056	AJ 126-216		
J1001		CONNECTOR: receptacle, bulkhead, 75 ohm series, straight,brass Pan Part J2078 (for serial nos. 151-300)	CC 3032		
J1001		CONNECTOR: receptacle, RF bulkhead, 75 ohm, snap-on series Pan Part J3012 (for serial nos. 301-350)	CC 3132		
J1003		CONNECTOR: receptacle, bulkhead, 75 ohm series, straight,brass Pan Part J2078 (for serial nos. 151-300)	CC 3032		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
J1003		CONNECTOR: receptacle, RF bulkhead, 75 ohm, snap-on series Pan Part J3012 (for serial nos. 301-350)	CC 3132		
J1005		CONNECTOR: receptacle, 5 contact, male Pan Part J2056	AJ 126-216		
J1007		CONNECTOR: receptacle, bulkhead, 75 ohm series, straight,brass Pan Part J2078 (for serial nos. 151-300)	CC 3032		
J1007		CONNECTOR: receptacle, RF bulkhead, 75 ohm, snap-on series Pan Part J3012 (for serial nos. 301-350)	CC 3132		
J1101		CONNECTOR: receptacle, bulkhead, 75 ohm series, straight,brass Pan Part J2078 (for serial nos. 151-300)	CC 3032		
J1101		CONNECTOR: receptacle, RF bulkhead, 75 ohm, snap-on series Pan Part J3012 (for serial nos. 301-350)	CC 3132		
J1103		CONNECTOR: receptacle, bulkhead, 75 ohm series, straight,brass Pan Part J2078 (for serial nos. 151-300)	CC 3032		
J1103		CONNECTOR: receptacle, RF bulkhead, 75 ohm, snap-on series Pan Part J3012 (for serial nos. 301-350)	CC 3132		
J1105		CONNECTOR: receptacle, 5 contact, male Pan Part J2056	AJ 126-216		
J1301		CONNECTOR: receptacle, 16 contact, female, chassis mount barrier, polarization Pan Part J2069	AJ 26-4100-16S	1	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
K101		RELAY: 3P-DT, 5 amp, 115 vac 160 ohms, 11 pin, octal plug-in with dust cover Pan Part S2055	AA GHP/3C/ 115 vac	2	
K103		RELAY: thermostatic, 60 second delay type, 9 pin min. plug-in type, 115 vac Pan Part S2056	AH 115N060t	1	
K105		RELAY: 3P-DT, 5 amp, 115 vac 160 ohms, 11 pin, octal plug-in with dust cover Pan Part S2055	AA GHP/3C 115 vac		
K107		RELAY: thermostatic, 5 second delay type, 9 pin miniature, plug-in type, 115 vac Pan Part S2057	AH 115N05t	1	
K109		RELAY: DP-DT, 115 vac Pan Part S2079	CQ 262C	3	
K111		RELAY: DP-DT, 115 vac Pan Part S2079	CQ 262C		
K113		RELAY: DP-DT, 115 vac Pan Part S2079	CQ 262C		
K301		RELAY: coaxial switch, remote operation, 4 position, single throw, 120 vdc Pan Part S2078	DG 300-11749 120 dc	1	
K401 A,B		RELAY: coaxial switch, DP-DT 115 vac, with Sealelectro Type 3032 connectors Pan Part S2081 (Serial Nos. 151-300)	AZ CR170	1	
K401 A,B		RELAY: coaxial switch, DP-DT 115 vac, FXR Series 321 with Type 27-15 subminax connectors Pan Part S3020 (serial nos. 301-up)	AZ 300-11071	1	
L301		COIL: RF choke, filament, 0.75 uh Pan Part L2039	BZ L2039		
L303		COIL: RF, choke, filament, 0.75 uh Pan Part L2039	BZ L2039		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
L304		COIL: choke, filament, triode, oscillator Pan Part Z1-11264A	BZ Z1-11264A	2	
L305		COIL: choke, filament, triode oscillator Pan Part Z1-11264A	BZ Z1-11264A		
L307		COIL: RF Pan Part ZN8475	BZ ZN8475	1	
L309		COIL: RF Pan Part ZN8476	BZ ZN8476	2	
L311		COIL: RF Pan Part ZN8476	BZ ZN8476		
L401		COIL: RF, 2.7 uh, $\pm 10\%$ Pan Part L3005	BX 9320-16	14	
L403		COIL: RF, 2.7 uh, $\pm 10\%$ Pan Part L3005	BX 9320-16		
L405		COIL: RF Pan Part ZN8477	BZ ZN8477	2	
L407		COIL: RF Pan Part ZN8484	BZ ZN8484	2	
L409		COIL: RF Pan Part ZN8479	BZ ZN8479	2	
L411		COIL: RF Pan Part ZN8478	BZ ZN8478	2	
L413		COIL: RF Pan Part ZN8481	BZ ZN8481	4	
L415		COIL: RF Pan Part ZN8480	BZ ZN8480	2	
L417		COIL: RF Pan Part ZN8481	BZ ZN8481		
L419		COIL: RF Pan Part ZN8482	BZ ZN8482	2	
L421		COIL: RF Pan Part ZN8485	BZ ZN8485	1	
L423		COIL: RF, 2.7 uh, $\pm 10\%$ Pan Part L3005	BX 9320-16		
L425		COIL: RF, 2.7 uf, $\pm 10\%$ Pan Part L3005	BX 9320-16		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
L429		COIL: RF, 2.7 uh, $\pm 10\%$ Pan Part L3005	BX 9320-16	6	
L430		COIL: RF, 2.7 uh, $\pm 10\%$ Pan Part L3005	BX 9320-16		
L431		COIL: RF, choke, 1.5 uh, $\pm 10\%$ Pan Part L3006	BX 9320-12		
L432		COIL: RF, 2.7 uh, $\pm 10\%$ Pan Part L3005	BX 9320-16		
L433		COIL: RF, 2.7 uh, $\pm 10\%$ Pan Part L3005	BX 9320-16		
L434		COIL: RF, choke, 1.5 uh, $\pm 10\%$ Pan Part L3006	BX 9320-12		
L435		COIL: RF Pan Part ZN8477	BZ ZN8477	1	
L437		COIL: tuning, 160 mc low pass filter Pan Part ZN8441	BZ ZN8441		
L438		COIL: tuning, 160 mc low pass filter Pan Part ZN8440	BZ ZN8440		
L439		COIL: tuning, bandpass filter Pan Part ZN8442	BZ ZN8442		
L440		COIL: tuning, bandpass filter Pan Part ZN8443	BZ ZN8443		
L441		COIL: tuning, bandpass filter Pan Part ZN8444	BZ ZN8444		
L447		COIL: RF, 2.7 uh, $\pm 10\%$ Pan Part L3005	BX 9320-16	1	
L449		COIL: RF, 2.7 uh, $\pm 10\%$ Pan Part L3005	BX 9320-16		
L451		COIL: RF, 2.7 uh, $\pm 10\%$ Pan Part L3005	BX 9320-16		
L455		COIL: RF, 2.7 uh, $\pm 10\%$ Pan Part L3005	BX 9320-16		
L457		COIL: RF Pan Part ZN8484	BZ ZN8484		
L459		COIL: tuning, RF, 160 mc wide band IF amp Pan Part ZN8478	BZ ZN8478		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
L463		COIL: RF, choke, 3.3 uh, $\pm 10\%$ Pan Part ZN8479	BZ ZN8479		
L465		COIL: tuning, RF, 160 mc wide band IF amp Pan Part ZN8480	BZ ZN8480		
L467		COIL: RF Pan Part ZN8481	BZ ZN8481		
L469		COIL: RF, 2.7 uh, $\pm 10\%$ Pan Part L3005	BX 9320-16		
L471		COIL: RF Pan Part ZN8482	BZ ZN8482		
L483		COIL: RF, 2.7 uh, $\pm 10\%$ Pan Part L3005	BX 9320-16		
L485		COIL: RF, choke, 1.5 uh, $\pm 10\%$ Pan Part L3006	BX 9320-12		
L487		COIL: RF, choke, 1.5 uh, $\pm 10\%$ Pan Part L3006	BX 9320-12		
L488		COIL: RF ZN8481	BZ ZN8481		
L489		COIL: RF Pan Part ZN8483	BZ ZN8483		
L601		INCREDUCTOR: controlable inductor Pan Part L3019	DF 81AM1	1	
L603		COIL: RF, choke, 1.5 uh, $\pm 10\%$ Pan Part L3006	BX 9320-12		
L605		COIL: tuning, RF, 160 mc wide band mixer Pan Part ZN8451	BZ ZN8451	1	
L607		COIL: RF, choke, filament, 0.75 uh Pan Part L2039	BZ L2039		
L608		COIL: RF, choke, 1.5 uh, $\pm 10\%$ Pan Part L3006	BX 9320-12		
L609		COIL: RF, choke, 3.3 uh, $\pm 10\%$ Pan Part L2038	CM 211-11	9	
L610		COIL: RF, choke, 3.3 uh, $\pm 10\%$ Pan Part L2038	CM 211-11		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
L611		COIL: RF, choke, filament, 0.75 uh Pan Part L2039	BZ L2039		
L625		COIL: RF, choke, 3.3 uh, $\pm 10\%$ Pan Part L2038	CM 211-11		
L627		COIL: RF, choke, 3.3 uh, $\pm 10\%$ Pan Part L2038	CM 211-11		
L701		COIL: RF, choke, 4.7 uh, $\pm 10\%$ Pan Part L2043	CM 213-11	1	
L703		COIL: RF, choke, filament, 0.75 uh Pan Part L2039	BZ L2039		
L705		COIL: RF, choke filament, 0.75 uh Pan Part L2039	BZ L2039		
L707		COIL: choke, ferrite core, 2.5 millihenry, 200 MA, 5.5 ohms Pan Part L2019	BX 6302	2	
L801		COIL: tuning, RF, 160 mc narrow band IF amp Pan Part ZN8452	BZ ZN8452	3	
L803		COIL: RF, choke, air core, close wound, 160 mc narrow band Pan Part ZN8426	BZ ZN8426	1	
L805		COIL: tuning, RF, 160 mc narrow band IF amp Pan Part ZN8452	BZ ZN8452		
L807		COIL: tuning, RF, 160 mc narrow band IF amp Pan Part ZN8452	BZ ZN8452		
L809		COIL: RF, choke, 3.3 uh, $\pm 10\%$ Pan Part L2038	CM 211-11		
L811		COIL: choke, ferrite core, 2.5 millihenry, 200 MA, 5.5 ohms Pan Part L2019	BX 6302		
L813		COIL: RF, choke, 3.3 uh, $\pm 10\%$ Pan Part L2038	CM 211-11		
L815		COIL: tuning, RF, 160 mc narrow band IF amp Pan Part ZN8453B	BZ ZN8453B		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
L817		COIL: RF, choke, 3.3 uh, $\pm 10\%$ Pan Part L2038	CM 211-11		
L819		COIL: tuning, RF, 160 mc narrow band IF amp Pan Part ZN8454	BZ ZN8454	1	
L821		COIL: RF, choke, 3.3 uh, $\pm 10\%$ Pan Part L2038	CM 211-11		
L823		COIL: tuning, RF, 160 mc narrow band IF amp Pan Part ZN8455A	BZ Z2-8455A	1	
L825		COIL: RF, choke, 3.3 uh, $\pm 10\%$ Pan Part L2038	CM 211-11		
L827		COIL: RF, choke, filament, 0.75 uh Pan Part L2039	BZ L2039		
L829		COIL: RF, choke, filament, 0.75 uh Pan Part L2039	BZ L2039		
L831		COIL: RF, choke, filament, 0.75 uh Pan Part L2039	BZ L2039		
L833		COIL: RF, choke, filament, 0.75 uh Pan Part L2039	BZ L2039		
L835		COIL: RF, choke filament, 0.75 uh Pan Part L2039	BZ L2039		
L1001		COIL: tuning, RF, 75 mc IF amp Pan Part ZN8493	BZ ZN8493	1	
L1003		COIL: tuning, RF, 75 mc IF amp Pan Part ZN8457	BZ ZN8457	3	
L1005		COIL: tuning, RF, 75 mc, IF amp Pan Part ZN8457	BZ ZN8457		
L1007		COIL: tuning, RF, 75 mc, IF amp Pan Part ZN8458	BZ ZN8458	1	
L1009		COIL: tuning, RF, 75 mc, IF amp Pan Part ZN8457	BZ ZN8457		
L1011		COIL: IF, 75 mc amp Pan Part ZN8468	BZ ZN8468	1	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
L1013		COIL: tuning, RF, 75 mc IF amp Pan Part ZN8459	BZ ZN8459	1	
L1015		COIL: RF, choke, 75 mc IF amp, .56 uh Pan Part ZN8427	BZ ZN8427	1	
L1017		COIL: RF, choke, filament, .75 uh Pan Part L2039	BZ L2039		
L1019		COIL: RF, choke, filament .75 uh Pan Part L2039	BZ L2039		
L1021		COIL: choke, video peaking 250 uh Pan Part L2068	BX 6181	1	
L1023		COIL: RF, choke, filament .75 uh Pan Part L2039	BZ L2039		
L1025		COIL: RF, choke, filament .75 uh Pan Part L2039	BZ L2039		
L1027		COIL: RF, choke, filament .75 uh Pan Part L2039	BZ L2039		
L1029		COIL: RF, choke, filament .75 uh Pan Part L2039	BZ L2039		
L1101		COIL: tuning, RF, 6.5 mc IF load coil Pan Part ZN8460	BZ ZN8460	2	
L1103		COIL: tuning, RF, 6.5 mc IF load coil Pan Part ZN8460	BZ ZN8460		
M301		MILLIAMETER: DC, 0-1 ma 25 ohms, $\pm 10\%$, sub-miniature Pan Part M1003	CU 100 W	1	
P103		CONNECTOR: plug, 90° angle, 5 contact, female Pan Part P2073	AR WK-5-23C-3/8"	1	
P105		CONNECTOR: plug, 90° angle, 19 contact, female Pan Part P2072	AR SK-19-23C- 1/2"	1	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
P106		CONNECTOR: plug, 2 wire, AC power Pan Part P2135	DE #183	1	
P111		CONNECTOR: plug, 90° angle, 14 contact, female Pan Part P2107	AR FK-B14-23C-9/16"	1	
P117		CONNECTOR: plug, 5 contact, male Pan Part P2078	AJ 126-217	1	
P119		DISCONNECT: high voltage, female Pan Part P2075	AD 8101F	1	
P308		CONNECTOR: plug, 4 prong, male Pan Part P2092	AJ 86-CP-4S	2	
P312		CONNECTOR: plug, 4 prong, male Pan Part P2092	AJ 86-CP-4S		
P314		CONNECTOR: plug, 12 pin, quick disconnect w/locking guides Pan Part J3011	CN QRE-12P-1		
P318		CONNECTOR: plug, 6 pin Pan Part J3004	DH MASE1-6		
P401		CONNECTOR: plug, 5 contact, female Pan Part P2095	AJ 126-223	8	
P403		CONNECTOR: plug, 5 contact, female Pan Part P2095	AJ 126-223		
P431		CONNECTOR: plug, miniature side mounting, two contacts Pan Part P2128	CN JFA2P	2	
P605		CONNECTOR: plug, 5 contact, female Pan Part P2095	AJ 126-223		
P703		CONNECTOR: plug, miniature, side mounting, two contacts Pan Part P2128	CN JFA2P		
P725		CONNECTOR: plug, 5 contact, female Pan Part P2095	AJ 126-223		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
P805		CONNECTOR: plug, 5 contact, female Pan Part P2095	AJ 126-223		
P807		CONNECTOR: plug, 5 contact, female Pan Part P2095	AJ 126-223		
P1005		CONNECTOR: plug, 5 contact, female Pan Part P2095	AJ 126-223		
P1105		CONNECTOR: plug, 5 contact, female Pan Part P2095	AJ 126-223		
P1301		CONNECTOR: plug, 16 contact, male, chassis mount, barrier polarization Pan Part J2068	AJ 26-4100-16P	1	
P1405		CONNECTOR: plug, high voltage disconnect, male, 15 KV Pan Part P2081	AD 8101M	1	
R101		RESISTOR: fixed, composition, 1 megohm, $\pm 5\%$, 2 W Pan Part RC42BX105J	AE HB1055	4	
R103		RESISTOR: fixed, composition, 1 megohm, $\pm 5\%$, 2 W Pan Part RC42BX105J	AE HB1055		
R105		RESISTOR: fixed, composition, 430 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX431J	AE EB4315	2	
R106		RESISTOR: fixed, precision metal film, 10,000 ohms, $\pm 1\%$, 1/2 W Pan Part RC20AZ103F	AU NA-15	1	
R107		RESISTOR: fixed, composition, 430 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX431J	AE EB4315		
R109		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX104J	AE EB1045	17	
R111		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX104J	AE EB1045		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
R113		RESISTOR: fixed, composition, 62,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX623J	AE EB6235	1	
R115		RESISTOR: fixed, composition, 1,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX102J	AE EB1025	9	
R117		RESISTOR: fixed, composition, 51,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX513J	AE EB5135	3	
R121		RESISTOR: fixed, composition, 6,200 ohms, $\pm 5\%$, 2 W Pan Part RC42BX622J	AE HB6225	1	
R123		RESISTOR: fixed, composition, 1,800 ohms, $\pm 5\%$, 2 W Pan Part RC42BX182J	AE HB1825	2	
R125		RESISTOR: fixed, wirewound, tab terminals, 25,000 ohms, 20 W Pan Part RW20X253R-4	CL 20F25000	3	
R127		RESISTOR: fixed, wirewound, tab terminals, 25,000 ohms, 20 W Pan Part RW20X253R-4	CL 20F25000		
R129		RESISTOR: fixed, wirewound, tab terminals, 25,000 ohms, 20 W Pan Part RW20X253R-4	CL 20F25000		
R131		RESISTOR: fixed, composition, 5,100 ohms, $\pm 5\%$, 2 W Pan Part RC42BX512J	AE HB5125	1	
R133		RESISTOR: fixed, composition, 20,000 ohms, $\pm 5\%$, 2 W Pan Part RC42BX203J	AE HB2035	5	
R135		RESISTOR: fixed, composition, 20,000 ohms, $\pm 5\%$, 2 W Pan Part RC42BX203J	AE HB2035		
R137		RESISTOR: fixed, composition, 20,000 ohms, $\pm 5\%$, 2 W Pan Part RC42BX203J	AE HB2035		
R139		RESISTOR: fixed, composition, 20,000 ohms, $\pm 5\%$, 2 W Pan Part RC42BX203J	AE HB2035		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
R141		RESISTOR: fixed, composition, 680 ohms, $\pm 5\%$, 2 W Pan Part RC42BX681J	AE EB6815	1	
R143		RESISTOR: fixed, wirewound, axial leads, 3.9 ohms, $\pm 5\%$, 1 W Pan Part RCW30AX3P9J	BQ Type BW-1	2	
R145		RESISTOR: fixed, composition, 75,000 ohms, $\pm 5\%$, 2 W Pan Part RC42BX753J	AE HB7535	2	
R147		RESISTOR: variable, composi- tion, linear, 10,000 ohms, $\pm 10\%$, 2 W Pan Part RV005	AE JA1N056S103UZ	4	
R149		RESISTOR: fixed, composition, 22,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX223J	AE EB2235	9	
R151		RESISTOR: fixed, composition, 82,000 ohms, $\pm 5\%$, 2 W Pan Part RC42BX823J	AE HB8235	3	
R153		RESISTOR: fixed, composition, 82,000 ohms, $\pm 5\%$, 2 W Pan Part RC42BX823J	AE HB8235		
R155		RESISTOR: fixed, composition, 82,000 ohms, $\pm 5\%$, 2 W Pan Part RC42BX823J	AE HB8235		
R157		RESISTOR: variable, composi- tion, linear, 100,000 ohms, $\pm 10\%$, 2 W Pan Part RV025	AE JA1N056S104UZ	5	
R159		RESISTOR: fixed, wirewound, axial wire leads, 5 ohms, $\pm 10\%$, 3 W Pan Part RW3X050KA-4	CL AX10HM3X5	5	
R160		RESISTOR: fixed, wirewound, axial wire leads, 5 ohms, $\pm 10\%$, 3 W Pan Part RW3X050KA-4	CL AX10HM3X5		
R161		RESISTOR: fixed, composition, 1 megohm, $\pm 5\%$, 1/2 W Pan Part RC20BX105J	AE EB1055	10	
R163		RESISTOR: fixed, composition, 43,000 ohms, $\pm 5\%$, 1/2 W (Nominal value) Pan Part RC20BX433J	AE EB4335	2	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
R165		RESISTOR: fixed, composition, 22,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX223J	AE EB2235		
R167		RESISTOR: fixed, composition, 22,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX223J	AE EB2235		
R169		RESISTOR: fixed, composition, 22,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX223J	AE EB2235		
R171		RESISTOR: fixed, composition, 22,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX223J	AE EB2235		
R173		RESISTOR: fixed, composition, 2 megohms, $\pm 5\%$, 1/2 W Pan Part RC20BX205J	AE EB2055	4	
R175		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX104J	AE GB1045	10	
R179		RESISTOR: fixed, composition, 820,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX824J	AE EB8245	3	
R181		RESISTOR: fixed, composition, 820,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX824J	AE EB8245		
R183		RESISTOR: fixed, composition, 180,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX184J	AE EB1845	3	
R185		RESISTOR: fixed, composition, 360,000 ohms, $\pm 5\%$, 1 W Pan Part RC20BX364J	AE EB3645	2	
R187		RESISTOR: variable, composi- tion, linear, 25,000 ohms, $\pm 10\%$, 2 W Pan Part RV026	AE JA1N056S253UZ	4	
R189		RESISTOR: fixed, composition, 91,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX913J	AE EB9135	2	
R190		RESISTOR: fixed, wirewound, axial wire leads, 5 ohms, $\pm 10\%$, 10 W Pan Part RW10X050KA-4	CL AXIOM10X5	1	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
R191		RESISTOR: fixed, composition, 1 megohm, $\pm 5\%$, 1/2 W Pan Part RC20BX105J	AE EB1055		
R192		RESISTOR: fixed, wirewound, axial wire leads, 5 ohms, $\pm 10\%$, 3 W Pan Part RW3X050KA-4	CL AX10HM3X5		
R193		RESISTOR: fixed, composition, 18,000 ohms, $\pm 5\%$, 1/2 W (Nominal value) Pan Part RC20BX183J	AE EB1835	1	
R195		RESISTOR: fixed, composition, 22,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX223J	AE EB2235		
R197		RESISTOR: fixed, composition, 22,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX223J	AE EB2235		
R199		RESISTOR: fixed, composition, 2 megohms, $\pm 5\%$, 1/2 W Pan Part RC20BX205J	AE EB2055		
R201		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX104J	AE GB1045		
R203		RESISTOR: fixed, composition, 680,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX684J	AE EB6845	2	
R205		RESISTOR: fixed, composition, 680,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX684J	AE EB6845		
R207		RESISTOR: fixed, composition, 180,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX184J	AE EB1845		
R209		RESISTOR: fixed, composition, 240,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX244J	AE EB2445	2	
R211		RESISTOR: variable, composi- tion, linear, 25,000 ohms, $\pm 10\%$, 2 W Pan Part RV026	AE JA1N056S253UZ		
R212		RESISTOR: fixed, wirewound, axial wire leads, 5 ohms, $\pm 10\%$, 3 W Pan Part RW3X050KA-4	CL AX10HM3X5		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
R213		RESISTOR: fixed, composition, 91,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX913J	AE EB9135		
R214		RESISTOR: fixed, wirewound, axial wire leads, 5 ohms, $\pm 10\%$, 3 W Pan Part RW3X050KA-4	CL AX10HM3X5		
R215		RESISTOR: fixed, composition, 3,300 ohms, $\pm 5\%$, 2 W Pan Part RC42BX332J	AE HB3325	2	
R217		RESISTOR: fixed, composition, 3,300 ohms, $\pm 5\%$, 2 W Pan Part RC42BX332J	AE HB3325		
R219		RESISTOR: fixed, composition, 2,700 ohms, $\pm 5\%$, 2 W Pan Part RC42BX272J	AE HB2725	1	
R221		RESISTOR: fixed, composition, 12,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX123J	AE GB1235	1	
R225		RESISTOR: fixed, wirewound, tab terminals, 75 ohms, 20 W Pan Part RW20X750R-4	CL 20F75	1	
R227		RESISTOR: fixed, composition, 24 ohms, $\pm 5\%$, 2 W Pan Part RC42BX240J	AE HB2405	1	
R229		RESISTOR: fixed, wirewound, tab terminals, 20 ohms, 20 W Pan Part RW20X200R-4	AL 20F20	2	
R230		RESISTOR: fixed, wirewound, 75 ohms, $\pm 10\%$, 10 W Pan Part RW10X750A-4	CL AX10M10X75	1	
R231		RESISTOR: fixed, wirewound, tab terminals, 20 ohms, 20 W Pan Part RW20X200R-4	CL 20F20		
R241		RESISTOR: fixed, composition, 330 ohms, $\pm 5\%$, 2 W Pan Part RC42BX331J	AE HB3315	1	
R243		RESISTOR: fixed, composition, 27,000 ohms, $\pm 5\%$, 2 W Pan Part RC42BX273J	AE HB2735	1	
R245		RESISTOR: fixed, composition, 100 ohms, $\pm 5\%$, 2 W Pan Part RC42BX101J	AE HB1015	1	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
R247		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX104J	AE EB1045		
R249		RESISTOR: fixed, composition, 1,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX102J	AE EB1025		
R251		RESISTOR: fixed, wirewound, axial leads, 2.7 ohms, $\pm 10\%$, 1/2 W Pan Part RCW20AX2P7K	BP Type BW-1/2	2	
R253		RESISTOR: fixed, wirewound, axial leads, 2.7 ohms, $\pm 10\%$, 1/2 W Pan Part RCW20AX2P7K	BP Type BW-1/2		
R303		RESISTOR: fixed, composition, 10,000 ohms, $\pm 5\%$, 2 W Pan Part RC42BX103J	AE HB1035	2	
R305		RESISTOR: fixed, composition, 300 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX301J	AE EB3015	2	
R306		RESISTOR: fixed, composition, 10,000 ohms, $\pm 5\%$, 2 W Pan Part RC42BX103J	AE HB1035		
R307		RESISTOR: variable, composi- tion, linear, 25,000 ohms, $\pm 10\%$, 1/2 W Pan Part RVM 406	AE GA1N040S253UZ	6	
R309		RESISTOR: variable, composi- tion, linear, 25,000 ohms, $\pm 10\%$, 1/2 W Pan Part RVM 406	AE GA1N040S253UZ		
R311		RESISTOR: variable, composi- tion, linear, 25,000 ohms, $\pm 10\%$, 1/2 W Pan Part RVM 406	AE GA1N040S253UZ		
R313		RESISTOR: variable, composi- tion, linear, 25,000 ohms, $\pm 10\%$, 1/2 W Pan Part RVM 406	AE GA1N040S253UZ		
R315		RESISTOR: variable, composi- tion, linear, 25,000 ohms, $\pm 10\%$, 1/2 W Pan Part RVM 406	AE GA1N040S253UZ		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
R317		RESISTOR: variable, composition, linear, 25,000 ohms, $\pm 10\%$, 1/2 W Pan Part RVM 406	AE GA1N040S253UZ		
R319		RESISTOR: fixed, wirewound, axial leads, 3.9 ohms, $\pm 5\%$, 1 W Pan Part RCW30AX3P9J	BQ Type BW-1		
R321		RESISTOR: fixed, composition, 300,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX304J	AE EB3045	3	
R323		RESISTOR: fixed, composition, 300,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX304J	AE EB3045		
R325		RESISTOR: fixed, composition, 390,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX394J	AE EB3945	1	
R327		RESISTOR: fixed, composition, 75 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX750J	AE EB7505	1	
R329		RESISTOR: fixed, composition, 330,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX334J	AE EB3345	1	
R330		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 2 W Pan Part RC42BX104J	AE HB1045	1	
R331		RESISTOR: fixed, composition, 360,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX364J	AE EB3645		
R333		RESISTOR: fixed, composition, 200,000 ohms, $\pm 5\%$, 2 W Pan Part RC42BX204J	AE HB2045	1	
R335		RESISTOR: fixed, composition, 1.3 megohms, $\pm 5\%$, 2 W Pan Part RC42BX135J	AE HB1355	1	
R337		RESISTOR: fixed, composition, 470,000 ohms, $\pm 5\%$, 2 W Pan Part RC42BX474J	AE HB4745	2	
R339		RESISTOR: fixed, composition, 1.5 megohms, $\pm 5\%$, 2 W Pan Part RC42BX155J	AE HB1555	1	
R341		RESISTOR: fixed, composition, 470,000 ohms, $\pm 5\%$, 2 W Pan Part RC42BX474J	AE HB4745		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
R343		RESISTOR: fixed, composition, 1 megohm, $\pm 5\%$, 2 W Pan Part RC42BX105J	AE HB1055	2	
R345		RESISTOR: fixed, composition, 1 megohm, $\pm 5\%$, 2 W Pan Part RC42BX105J	AE HB1055		
R347		RESISTOR: fixed, composition, 1.8 megohm, $\pm 5\%$, 2 W Pan Part RC42BX185J	AE HB1855	1	
R349		RESISTOR: fixed, composition, 2.2 megohms, $\pm 5\%$, 2 W Pan Part RC42BX225J	AE HB2255	1	
R350		RESISTOR: fixed, wirewound, axial leads, 3,500 ohms, $\pm 5\%$, 5 W Pan Part RW5X352A-1	CE Type 27E	1	
R351		RESISTOR: fixed, composition, 240 ohms, $\pm 5\%$, 1/4 W Pan Part RC10BX241J	AE CB2415	1	
R353		RESISTOR: fixed, composition, 2,200 ohms, $\pm 5\%$, 1/4 W Pan Part RC10BX222J	AE CB2225	1	
R355		RESISTOR: fixed, composition, 51 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX510J	AE EB5105	3	
R356		RESISTOR: fixed, wirewound, 1 ohm, $\pm 5\%$, 1 W Pan Part RCW30X010R-3	BQ BW-1	1	
R357		RESISTOR: fixed, composition, 20,000 ohms, $\pm 5\%$, 2 W Pan Part RC42BX203J	AE HB2035		
R358		RESISTOR: fixed, composition, 10,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX103J	AE EB1035	13	
R359		RESISTOR: fixed, composition, very high frequency, 50 ohms, $\pm 5\%$, 1/8 W Pan Part RFX-1000	BF MR060	1	
R360		RESISTOR: fixed, wirewound, 1/2 ohm, $\pm 10\%$, 3 W Pan Part RW3X0P5A-4	CL 3X0.5		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
R361		RESISTOR: variable, composition, linear, 3,000 ohms, $\pm 10\%$, 2 W Pan Part RV011	AE JA1N056S302UZ	3	
R362		RESISTOR: fixed, wirewound, 2 ohms, $\pm 10\%$, 5 W Pan Part RW5X020A-4	CL 5X2	2	
R363		RESISTOR: variable, composition, linear, 25,000 ohms, $\pm 10\%$, 2 W Pan Part RV026	AE JA1N056S253UZ		
R364		RESISTOR: fixed, composition, 27,000 ohms, $\pm 5\%$, 2 W Pan Part RC42BX273J	AE HB2735	1	
R365		RESISTOR: fixed, composition, 150,000 ohms, $\pm 5\%$, 2 W Pan Part RC42BX154J	AE HB1545	1	
R366		RESISTOR: variable, composition, linear, 500,000 ohms, $\pm 10\%$, 2 W Pan Part RV015	AE JA1N056S504UZ	2	
R367		RESISTOR: variable, composition, linear, 100,000 ohms, $\pm 10\%$, 2 W Pan Part RV025	AE JA1N056S104UZ		
R368		RESISTOR: variable, composition, linear, 250,000 ohms, $\pm 10\%$, 2 W Pan Part RV024	AE JA1N056S254UZ		
R369 A,B		RESISTOR: variable, wirewound, dual, precision, 200,000 ohms / 200,000 ohms, $\pm 2\%$, 8 W nominal / section Pan Part RVX-916	BZ RVX-916	1	
R370		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX104J	AE EB1045		
R371		RESISTOR: fixed, composition, 390,000 ohms, $\pm 5\%$, 2 W Pan Part RC42BX394J	AE HB3945	2	
R372		RESISTOR: fixed, composition, 2,700 ohms, $\pm 5\%$, 2 W Pan Part RC42BX272J	AE HB2725	1	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
R373		RESISTOR: fixed, composition, 5,600 ohms, $\pm 5\%$, 1 W Pan Part RC32BX562J	AE GB5625	2	
R374		RESISTOR: fixed, composition, 24,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX243J	AE EB2435	1	
R375		RESISTOR: fixed, composition film, very high frequency, 50 ohms, $\pm 5\%$, 1/8 W Pan Part RFX-1001	BF MR060	2	
R376		RESISTOR: fixed, composition, 10 ohms, $\pm 5\%$, 2 W Pan Part RC42BX100J	AE HB1005	1	
R377		RESISTOR: variable, composition, linear, 10,000 ohms, $\pm 10\%$, 2 W Pan Part RV005	AE JA1N056S103UZ		
R378		RESISTOR: fixed, wirewound, 2 ohm, $\pm 10\%$, 5 W Pan Part RW5X020A-4	CL 5X2		
R379		RESISTOR: variable, composition, linear, 100,000 ohms, $\pm 10\%$, 2 W Pan Part RV025	AE JA1056S104UZ		
R380		RESISTOR: fixed, wirewound, 1/2 ohm, $\pm 10\%$, 3 W Pan Part RW3X0P5A-4	CL 3X0.5		
R381		RESISTOR: variable, composition, linear, 25,000 ohms, $\pm 10\%$, 2 W Pan Part RV026	AE JA1N056S253UZ		
R382		RESISTOR: fixed, composition, 10,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX103J	AE EB1035		
R383		RESISTOR: variable, composition, linear, 50,000 ohms, $\pm 10\%$, 2 W Pan Part RV014	AE JA1N056S503UZ	4	
R385		RESISTOR: variable, composition, linear, 100,000 ohms, $\pm 10\%$, 2 W Pan Part RV025	AE JA1N056S104UZ		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
R387		RESISTOR: fixed, composition, 75,000 ohms, $\pm 5\%$, 2 W Pan Part RC42BX753J	AE HB7535	1	
R391		RESISTOR: fixed, composition, 390,000 ohms, $\pm 5\%$, 2 W Pan Part RC42BX394J	AE HB3945		
R393		RESISTOR: fixed, composition, 5,600 ohms, $\pm 5\%$, 1 W Pan Part RC32BX562J	AE GB5625		
R395		RESISTOR: fixed, composition film, very high frequency, 50 ohms, $\pm 10\%$, 1/4 W Pan Part RFX-1002	BQ HFR		
R396		RESISTOR: fixed, wirewound, 5,000 ohms, $\pm 10\%$, 5 W Pan Part RW5X502R-6	CW Type FRL-5 5000 ohm	1	
R397		RESISTOR: fixed, composition film, very high frequency, 50 ohms, $\pm 10\%$, 1/4 W Pan Part RFX-1002	BQ HFR		
R398		RESISTOR: fixed, composition film, very high frequency, 50 ohms, $\pm 5\%$, 1/8 W Pan Part RFX-1001	BF MR060		
R399		RESISTOR: fixed, composition film, very high frequency, 50 ohms, $\pm 10\%$, 1/4 W Pan Part RFX-1002	BQ HFR		
R401		RESISTOR: fixed, composition, 62 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX620J	AE EB6205	4	
R403		RESISTOR: fixed, composition, 62 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX620J	AE EB6205		
R405		RESISTOR: fixed, wirewound, 1,200 ohms, 5 W Pan Part RW5X122A-1	CD 452E1225	2	
R407		RESISTOR: fixed, composition, 560 ohms, $\pm 5\%$, 1/2 W (used as coil form for L421) Pan Part RC20BX561J	AE EB5615	3	
R409		RESISTOR: fixed, composition, 33 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX330J	AE EB3305	3	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
R411		RESISTOR: fixed, composition, 560 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX561J	AE EB5615		
R430		RESISTOR: fixed, composition, 62 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX620J	AE EB6205		
R432		RESISTOR: fixed, composition, 62 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX620J	AE EB6205		
R433		RESISTOR: fixed, wirewound, 1,200 ohms, 5 W Pan Part RW5X122A-1	CD 452E1225		
R434		RESISTOR: fixed, composition, 91 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX910J	AE EB9105		
R437		RESISTOR: fixed, composition, 51 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX510J	AE EB5105		
R438		RESISTOR: fixed, composition, 33 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX330J	AE EB3305		
R440		RESISTOR: fixed, composition, 15 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX150J	AE EB1505	2	
R442		RESISTOR: fixed, composition, 15 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX150J	AE EB1505		
R444		RESISTOR: fixed, composition, 150 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX151J	AE EB1515		
R602		RESISTOR: fixed, composition, 200,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX204J	AE EB2045	1	
R603		RESISTOR: fixed, composition, 1,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX102J	AE GB1025	2	
R604		RESISTOR: fixed, composition, 1 megohm, $\pm 5\%$, 1/2 W Pan Part RC20BX105J	AE EB1055		
R605		RESISTOR: fixed, composition, 240,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX244J	AE EB2445		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. IN Set	Qty. 3 Mo. Opn.
R606		RESISTOR: fixed, composition, 470,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX474J	AE EB4745	4	
R608		RESISTOR: fixed, composition, 1,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX102J	AE EB1025		
R610		RESISTOR: variable, composi- tion, linear, 500,000 ohms, $\pm 20\%$, 2 W Pan Part RV015	AE JA1N056S504UZ		
R612		RESISTOR: fixed, composition, 68,000 ohms, $\pm 5\%$, 2 W Pan Part RC42BX683J	AE HB6835	1	
R614		RESISTOR: fixed, composition, 2 megohms, $\pm 5\%$, 1/2 W Pan Part RC20BX205J	AE EB2055	1	
R616		RESISTOR: fixed, composition, 10,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX103J	AE GB1035		
R621		RESISTOR: variable, composi- tion, linear, 100,000 ohms, $\pm 10\%$, 2 W Pan Part RV025	AE JA1N056S104UZ		
R622		RESISTOR: fixed, composition, 33,000 ohms, $\pm 5\%$, 2 W Pan Part RC42BX333J	AE HB3335		
R623		RESISTOR: fixed, composition, 820 ohms, $\pm 5\%$, 1 W Pan Part RC32BX821J	AE GB8215	1	
R624		RESISTOR: fixed, composition, 4.7 megohms, $\pm 5\%$, 1/2 W Pan Part RC20BX475J	AE EB4755	4	
R625		RESISTOR: fixed, composition, 51,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX513J	AE EB5135		
R629		RESISTOR: fixed, composition, 120,000 ohms, $\pm 5\%$, 2 W Pan Part RC42BX124J	AE HB1245	1	
R630		RESISTOR: fixed, composition, 10 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX100J	AE EB1005	1	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
R631		RESISTOR: fixed, composition, 1,200 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX122J	AE EB1225	2	
R632		RESISTOR: fixed, composition, 560 ohms, $\pm 5\%$, 1/2 W (used as coil form for L421) Pan Part RC20BX561J	AE EB5615		
R633		RESISTOR: fixed, composition, 430,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX434J	AE EB4345	1	
R635		RESISTOR: variable, composi- tion, linear, 3,000 ohms, $\pm 10\%$, 2 W Pan Part RV 011	AE JA1N056S302UA		
R637 A,B		RESISTOR: variable, composi- tion, linear, dual, 500 ohm / 500 ohm, $\pm 10\%$, 2 W Pan Part RVT 500	AE JD1N056S501UA	1	
R701		RESISTOR: fixed, composition, 47,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX473J	AE EB4735	2	
R703		RESISTOR: fixed, composition, 68 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX680J	AE EB6805	2	
R705		RESISTOR: fixed, composition, 47,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX473J	AE EB4735		
R707		RESISTOR: fixed, composition, 510 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX511J	AE EB5115		
R709		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX104J	AE EB1045		
R711		RESISTOR: fixed, composition, 1,200 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX122J	AE EB1225		
R713		RESISTOR: fixed, composition, 1 megohm, $\pm 5\%$, 1/2 W Pan Part RC20BX105J	AE EB1055		
R715		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX104J	AE GB1045		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
R801		RESISTOR: fixed, composition, 680 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX681J	AE EB6815	2	
R803		RESISTOR: fixed, composition, 4,700 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX472J	AE EB4725		
R805		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX104J	AE EB1045		
R807		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX104J	AE EB1045		
R809		RESISTOR: fixed, composition, 100 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX101J	AE EB1015	7	
R811		RESISTOR: fixed, composition, 10,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX103J	AE EB1035		
R813		RESISTOR: fixed, composition, 220,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX224J	AE EB2245	9	
R815		RESISTOR: fixed, composition, 12,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX123J	AE EB1235	2	
R817		RESISTOR: fixed, composition, 620 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX621J	AE EB6215	2	
R819		RESISTOR: fixed, composition, 10,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX103J	AE EB1035		
R821		RESISTOR: fixed, composition, 100 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX101J	AE EB1015	2	
R823		RESISTOR: fixed, composition, 4,700 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX472J	AE EB4725		
R825		RESISTOR: fixed, composition, 12,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX123J	AE EB1235		
R827		RESISTOR: fixed, composition, 620 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX621J	AE EB6215		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
R829		RESISTOR: fixed, composition, 10,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX103J	AE EB1035	5	
R831		RESISTOR: fixed, composition, 240 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX241J	AE EB2415		
R832		RESISTOR: fixed, composition, 1 megohm, $\pm 5\%$, 1/2 W Pan Part RC20BX105J	AE EB1055		
R833		RESISTOR: fixed, composition, 470,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX474J	AE EB4745		
R835		RESISTOR: fixed, composition, 39,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX393J	AE GB3935	1	
R837		RESISTOR: fixed, composition, 24,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX243J	AE GB2435	1	
R839		RESISTOR: fixed, composition, 820 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX821J	AE EB8215	2	
R841		RESISTOR: fixed, composition, 1600 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX162J	AE EB1625	1	
R843		RESISTOR: fixed, composition, 15,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX153J	AE EB1535		
R845		RESISTOR: fixed, composition, 220 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX221J	AE EB2215		
R847		RESISTOR: fixed, composition, 220,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX224J	AE EB2245	1	
R849		RESISTOR: fixed, composition, 220,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX224J	AE GB2245		
R851		RESISTOR: fixed, composition, 10,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX103J	AE EB1035		
R853		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX104J	AE GB1045		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
R855		RESISTOR: variable, composition, linear, 3,000 ohms, $\pm 10\%$, 2 W Pan Part RV011	AE JA1N056S302UA		
R857		RESISTOR: fixed, wirewound, 15 ohm, $\pm 10\%$, 5 W Pan Part RW5X150A-4	CL AX10M-5X15	1	
R1001		RESISTOR: fixed, composition, 1,300 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX132J	AE EB1325		
R1003		RESISTOR: fixed, composition, 62,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX623J	AE GB6235	7	
R1005		RESISTOR: fixed, composition, 1,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX102J	AE EB1025		
R1007		RESISTOR: fixed, composition, 47 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX470J	AE EB4705	6	
R1009		RESISTOR: fixed, composition, 130 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX131J	AE EB1315	5	
R1011		RESISTOR: variable, composition, linear, 10,000 ohms, $\pm 10\%$, 2 W Pan Part RV005	AE JA1N056S103UZ		
R1013		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX104J	AE GB1045		
R1015		RESISTOR: fixed, composition, 3,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX302J	AE EB3025	2	
R1017		RESISTOR: fixed, composition, 62,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX623J	AE GB6235		
R1019		RESISTOR: fixed, composition, 47 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX470J	AE EB4705		
R1021		RESISTOR: fixed, composition, 130 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX131J	AE EB1315		
R1023		RESISTOR: fixed, composition, 1,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX102J	AE EB1025		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
R1025		RESISTOR: fixed, composition, 62,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX623J	AE GB6235	2	
R1027		RESISTOR: fixed, composition, 51,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX512J	AE EB5125		
R1029		RESISTOR: fixed, composition, 47 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX470J	AE EB4705		
R1031		RESISTOR: fixed, composition, 130 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX131J	AE EB1315		
R1033		RESISTOR: fixed, composition, 1,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX102J	AE GB1025	3	
R1035		RESISTOR: fixed, composition, 62,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX623J	AE GB6235		
R1037		RESISTOR: fixed, composition, 5,600 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX562J	AE EB5625		
R1039		RESISTOR: fixed, composition, 180 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX181J	AE EB1815		
R1041		RESISTOR: fixed, composition, 5,600 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX562J	AE EB5625	1	
R1043		RESISTOR: fixed, composition, 1,200 ohms, $\pm 5\%$, 1 W Pan Part RC32BX122J	AE GB1225		
R1045		RESISTOR: fixed, composition, 22,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX223J	AE EB2235		
R1047		RESISTOR: fixed, composition, 68 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX680J	AE EB6805		
R1049		RESISTOR: fixed, composition, 15,000 ohms, $\pm 5\%$, 2 W Pan Part RC42BX153J	AE HB1535	1	
R1051		RESISTOR: fixed, composition, 3,900 ohms, $\pm 5\%$, 1 W Pan Part RC20BX392J	AE GB3925	1	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
R1053		RESISTOR: fixed, composition, 51 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX510J	AE EB5105		
R1055		RESISTOR: fixed, composition, 240 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX241J	AE EB2415		
R1056		RESISTOR: fixed, composition, 680 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX681J	AE EB6815		
R1057		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX104J	AE EB1045		
R1058		RESISTOR: fixed, composition, 8,200 ohms, $\pm 5\%$, 1 W Pan Part RC32BX822J	AE GB8225	2	
R1059		RESISTOR: fixed, composition, 8,200 ohms, $\pm 5\%$, 1 W Pan Part RC32BX822J	AE GB8225		
R1061		RESISTOR: fixed, composition, 240 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX241J	AE EB2415		
R1063		RESISTOR: fixed, composition, 51,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX513J	AE EB5135	3	
R1065		RESISTOR: fixed, composition, 10,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX103J	AE EB1035		
R1067		RESISTOR: fixed, composition, 10,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX103J	AE EB1035		
R1069		RESISTOR: fixed, composition, 10,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX103J	AE EB1035		
R1071		RESISTOR: fixed, composition, 160 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX161J	AE EB1615	1	
R1073		RESISTOR: fixed, composition, 1,800 ohms, $\pm 5\%$, 2 W Pan Part RC42BX182J	AE HB1825		
R1075		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX104J	AE EB1045		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
R1077		RESISTOR: fixed, composition, 300 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX301J	AE EB3015	4	
R1079		RESISTOR: fixed, composition, 10,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX103J	AE EB1035		
R1101		RESISTOR: fixed, composition, 4,300 ohms, $\pm 5\%$, 1 W Pan Part RC32BX432J	AE GB4325		
R1103		RESISTOR: fixed, composition, 62,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX623J	AE GB6235		
R1105		RESISTOR: fixed, composition, 1 megohm, $\pm 5\%$, 1/2 W Pan Part RC20BX105J	AE EB1055		
R1107		RESISTOR: fixed, composition, 47 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX470J	AE EB4705		
R1109		RESISTOR: fixed, composition, 130 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX131J	AE EB1315		
R1111		RESISTOR: variable, composi- tion, linear, 10,000 ohms, $\pm 10\%$, 2 W Pan Part RV005	AE JA1N056S103UZ		
R1113		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX104J	AE GB1045		
R1115		RESISTOR: fixed, composition, 1,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX102J	AE EB1025		
R1117		RESISTOR: fixed, composition, 100 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX101J	AE EB1015		
R1119		RESISTOR: fixed, composition, 1 megohm, $\pm 5\%$, 1/2 W Pan Part RC20BX105J	AE EB1055		
R1121		RESISTOR: fixed, composition, 100 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX101J	AE EB1015		
R1123		RESISTOR: fixed, composition, 240 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX241J	AE EB2415		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
R1125 A,B		RESISTOR: variable, composition, log taper, dual, 100,000/100,000 ohms, $\pm 10\%$, 2 W Pan Part RVT 501	AE JD1N056S104AA	1	
R1127		RESISTOR: fixed, composition, 62,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX623J	AE GB6235		
R1128		RESISTOR: fixed, composition, 47 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX470J	AE EB4705		
R1129		RESISTOR: fixed, composition, 4,300 ohms, $\pm 5\%$, 1 W Pan Part RC32BX432J	AE GB4325		
R1131		RESISTOR: fixed, composition, 180 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX181J	AE EB1815		
R1133		RESISTOR: fixed, composition, 1,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX102J	AE EB1025		
R1135		RESISTOR: fixed, composition, 100 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX101J	AE EB1015		
R1137		RESISTOR: fixed, composition, 1 megohm, $\pm 5\%$, 1/2 W Pan Part RC20BX105J	AE EB1055		
R1138		RESISTOR: fixed, composition, 47 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX470J	AE EB4705		
R1139		RESISTOR: fixed, composition, 100 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX101J	AE EB1015		
R1141		RESISTOR: fixed, composition, 240 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX241J	AE EB2415		
R1145		RESISTOR: fixed, composition, 62,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX623J	AE GB6235		
R1147		RESISTOR: fixed, composition, 4,300 ohms, $\pm 5\%$, 1 W Pan Part RC32BX432J	AE GB4325		
R1149		RESISTOR: fixed, composition, 180 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX181J	AE EB1815		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
R1151		RESISTOR: fixed, composition, 22,000 ohms, $\pm 5\%$, 2 W Pan Part RC42BX223J	AE HB2235	1	
R1153		RESISTOR: fixed, composition, 5,100 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX512J	AE EB5125		
R1155		RESISTOR: variable, composition, linear, 50,000 ohms, $\pm 10\%$, 2 W Pan Part RV014	AE JA1N056S503UZ		
R1157		RESISTOR: fixed, composition, 4,300 ohms, $\pm 5\%$, 1 W Pan Part RC32BX432J	AE GB4325		
R1159		RESISTOR: fixed, composition, 10,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX103J	AE GB1035		
R1161		RESISTOR: fixed, composition, 33 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX330J	AE EB3305		
R1163		RESISTOR: fixed, composition, 130 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX131J	AE EB1315		
R1165		RESISTOR: variable, composition, linear, 1000 ohms, $\pm 10\%$, 1/2 W Pan Part RVM401	AE RU2-22401		
R1167		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX104J	AE EB1045		
R1169		RESISTOR: fixed, composition, 56,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX563J	AE EB5635	2	
R1171		RESISTOR: variable, composition, linear, 50,000 ohms, $\pm 10\%$, 2 W Pan Part RV014	AE JA1N056S503UZ		
R1201		RESISTOR: fixed, composition, 51,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX513J	AE EB5135		
R1203		RESISTOR: fixed, composition, 51,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX513J	AE GB5135		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
R1205		RESISTOR: fixed, composition, 150,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX154J	AE GB1545	1	
R1207		RESISTOR: fixed, composition, 620,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX624J	AE EB6245	1	
R1209		RESISTOR: fixed, composition, 51,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX513J	AE GB5135		
R1211		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX104J	AE GB1045		
R1213		RESISTOR: fixed, composition, 4.7 megohms, $\pm 5\%$, 1/2 W Pan Part RC20BX475J	AE EB4755		
R1215		RESISTOR: fixed, composition, 200 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX201J	AE EB2015		
R1217		RESISTOR: fixed, composition, 43,000 ohms, $\pm 5\%$, 1/2 W (Nominal value) Pan Part RC20BX433J	AE EB4335	2	
R1219		RESISTOR: variable, composi- tion, linear, 5,000 ohms, $\pm 10\%$, 1/2 W Pan Part RVM-405	AE GA1N040S502UZ	3	
R1221		RESISTOR: fixed, composition, 750 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX751J	AE EB7515		
R1223		RESISTOR: fixed, composition, 220,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX224J	AE EB2245		
R1225		RESISTOR: fixed, composition, 47,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX473J	AE GB4735		
R1227		RESISTOR: fixed, composition, 56,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX563J	AE EB5635		
R1228		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX104J	AE EB1045		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
R1229		RESISTOR: variable, composition, linear, 5,000 ohms, $\pm 10\%$, 1/2 W Pan Part RVM-405	AE GA1N040S502UZ		
R1230		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX104J	AE EB1045		
R1231		RESISTOR: fixed, composition, 33,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX333J	AE EB3335	1	
R1232		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX104J	AE EB1045		
R1233		RESISTOR: fixed, composition, 220,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX224J	AE EB2245		
R1234		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX104J	AE EB1045		
R1235		RESISTOR: fixed, composition, 820 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX821J	AE EB8215		
R1236		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX104J	AE EB1045		
R1237		RESISTOR: fixed, composition, 220,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX224J	AE EB2245		
R1239		RESISTOR: fixed, composition, 470,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX474J	AE EB4745		
R1240		RESISTOR: fixed, composition, 22,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX223J	AE EB2235		
R1241		RESISTOR: fixed, composition, 6,800 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX682J	AE EB6825	1	
R1242		RESISTOR: fixed, composition, 220,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX224J	AE EB2245		
R1243		RESISTOR: fixed, composition, 300,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX304J	AE EB3045		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
R1245		RESISTOR: fixed, composition, 10,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX103J	AE EB1035		
R1247		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX104J	AE GB1045		
R1249		RESISTOR: variable, composi- tion, linear, 50,000 ohms, $\pm 10\%$, 2 W Pan Part RV014	AE JA1N056S503UZ		
R1301		RESISTOR: fixed, composition, 470 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX471J	AE EB4715	1	
R1303		RESISTOR: fixed, composition, 1 megohm, $\pm 5\%$, 1/2 W Pan Part RC20BX105J	AE EB1055		
R1305		RESISTOR: fixed, composition, 220,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX224J	AE EB2245		
R1307		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX104J	AE EB1045		
R1309		RESISTOR: fixed, composition, 39,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX393J	AE EB3935	1	
R1310		RESISTOR: fixed, composition, 1,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX102J	AE EB1025		
R1311		RESISTOR: fixed, composition, 1 megohm, $\pm 5\%$, 1/2 W Pan Part RC20BX105J	AE EB1055		
R1313		RESISTOR: fixed, composition, 100 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX101J	AE EB1015		
R1314		RESISTOR: fixed, composition, 3,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX302J	AE EB3025		
R1315		RESISTOR: variable, composi- tion, linear, special shaft, (includes S1301A, B) 50,000 ohms, $\pm 10\%$, 2 W Pan Part RV 036	BZ RV-036	1	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
R1317		RESISTOR: fixed, composition, 10,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX103J	AE EB1035		
R1319		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX104J	AE GB1045		
R1321		RESISTOR: fixed, composition, 470,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX474J	AE EB4745		
R1323		RESISTOR: fixed, composition, 820,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX824J	AE EB8245		
R1325 A,B		RESISTOR: variable, composi- tion, linear, dual, 50,000 ohms, 5 meg, $\pm 20\%$, 2 W Pan Part RVT 503	AE JJU-5032/5052 Shaft style SD3056	1	
R1327		RESISTOR: fixed, composition, 2,400 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX242J	AE EB2425		
R1331		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX104J	AE EB1045		
R1333		RESISTOR: fixed, composition, 18,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX183J	AE GB1835		
R1335		RESISTOR: fixed, composition, 15,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX153J	AE EB1535		
R1337		RESISTOR: variable, composi- tion, linear, 5 megohms, $\pm 20\%$, 1/2 W Pan Part RVM 408	AE GA1N040S505MZ	2	
R1338		RESISTOR: fixed, composition, 2 megohms, $\pm 5\%$, 1/2 W Pan Part RC20BX205J	AE EB2055		
R1339		RESISTOR: fixed, composition, 4.7 megohms, $\pm 5\%$, 1/2 W Pan Part RC20BX475J	AE EB4755		
R1341		RESISTOR: fixed, composition, 220,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX224J	AE EB2245		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
R1343		RESISTOR: fixed, composition, 100,000 ohms, $\pm 5\%$, 1 W Pan Part RC32BX104J	AE GB1045		
R1345		RESISTOR: fixed, composition, 2.2 megohms, $\pm 5\%$, 1/2 W Pan Part RC20BX225J	AE EB2255	1	
R1347		RESISTOR: variable, composition, linear, 5,000 ohms, $\pm 10\%$, 1/2 W Pan Part RVM 405	AE GA1N040S502UZ		
R1349		RESISTOR: fixed, composition, 1,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX102J	AE EB1025		
R1351		RESISTOR: fixed, composition, 1.8 megohms, $\pm 5\%$, 1/2 W Pan Part RC20BX185J	AE EB1855	1	
R1353		RESISTOR: fixed, composition, 220,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX224J	AE EB2245		
R1355		RESISTOR: fixed, composition, 75,000 ohms, $\pm 5\%$, 2 W Pan Part RC42BX753J	AE HB7535		
R1357		RESISTOR: fixed, composition, 180,000 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX184J	AE EB1845		
R1359		RESISTOR: fixed, composition, 5,600 ohms, $\pm 5\%$, 1/2 W Pan Part RC20BX562J	AE EB5625		
R1360		RESISTOR: fixed, composition, 4.7 megohms, $\pm 5\%$, 1/2 W Pan Part RC20BX475J	AE EB4755		
R1361 A,B		RESISTOR: variable, composition, linear, dual special shaft, 1 meg/1 meg, $\pm 20\%$, 2 W (includes S401) Pan Part RVT 514	BZ RVT-514	1	
R1363		RESISTOR: variable, composition, linear, 1 megohm, $\pm 20\%$, 1/2 W Pan Part RVM 407	AE GA1N040S505MZ	1	
R1365		RESISTOR: variable, composition, linear, 5 megohms, $\pm 20\%$, 1/2 W Pan Part RVM 408	AE GA1N040S505MZ		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
R1401		RESISTOR: fixed, composition, 5.1 megohms, $\pm 5\%$, 2 W Pan Part RC42BX515J	AE HB5155	2	
R1403		RESISTOR: fixed, composition, 5.1 megohms, $\pm 5\%$, 2 W Pan Part RC42BX515J	AE HB5155		
R1405		RESISTOR: variable, composition, linear, 5 megohms, $\pm 20\%$, 2 W Pan Part RVX 908	AE JA1N044S505MZ	1	
R1407		RESISTOR: fixed, composition, 3 megohms, $\pm 5\%$, 1 W Pan Part RC32BX305J	AE GB3055	1	
R1409		RESISTOR: variable, composition, linear, 1 megohm, $\pm 20\%$, 2 W Pan Part RVX 907	AE JA1N044S105MZ	1	
R1411		RESISTOR: fixed, composition, 1.5 megohms, $\pm 5\%$, 1/2 W Pan Part RC20BX155J	AE EB1555	1	
R1413		RESISTOR: variable, wirewound, linear, with SPST switch (Ref Sym S1401) 6 ohms, $\pm 10\%$, 2 W Pan Part RVS-700	AT Type GC -252	1	
RV601		VARISTOR: 3.0 V to 5.5 V at 20 ua, 6.0 V to 11.0 V at 200 ua Pan Part RV -5001	CP 114W3	1	
S301		SWITCH: toggle, DP-ST Pan Part S2021N	AM 81024GB	1	
S302		SWITCH: push button, 6 buttons Pan Part S2062	BZ S2062	1	
S303		SWITCH: precision, ultra small 1P-DT Pan Part S2008-1	BU V3-1	2	
S304		SWITCH: push button, momentary contact, two circuit "JR" series Pan Part S2066	DJ C2002	1	
S305		SWITCH: rotary, ceramic, miniature, single deck, 2P/2-6T, non-shorting contacts, adjustable stop Pan Part S2067	BZ S2067	1	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
S306		SWITCH: precision, ultra small 1P-DT Pan Part S2008-1	BU V3-1		
S307		SWITCH: RF, coaxial, 1P-4T Pan Part S3-1307	BZ S3-13071	2	
S308		SWITCH: RF coaxial, 1P-4T Pan Part S3-13071	BZ S3-13071		
S309		SWITCH: rotary, 6 position, detent, no stops Pan Part S1-12118C	BZ S1-12118C	1	
S311*		SWITCH: subminiature, snap action, SP-DT Pan Part S2033-1	BU 1SM1	2	
S401		SWITCH: concentric, rotary, and dual 1 meg potentiometer R1361A and B Pan Part S2-11339C	BZ S2-11339C	1	
S701		SWITCH: subminiature, snap action, SP-DT Pan Part S2033-1	BU 1SM1		
S1101 A,B,C		SWITCH: rotary, circuit selec- tor, miniature, 3P/2-3T, single deck phenolic wafer Pan Part S2061	BZ S2061	1	
S1201		SWITCH: rotary, circuit selec- tor, 1P-3T single deck, bake- lite wafer Pan Part S1026	BZ S1026	1	
S1301		SWITCH: concentric, rotary, and potentiometer assembly (2P-3T switch and 50 K potentiometer E1315) Pan Part S2-11338C	BZ S2-11338C	1	
S1401		See R1413.			
T101		TRANSFORMER: power, high voltage, plate Pan Part T2-12129C	BZ T2-12129C	1	
T102		TRANSFORMER: power, high voltage, filament Pan Part T2-12128C	BZ T2-12128C	1	

*For serial nos. 169 and above (except No. 170)

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
T103		TRANSFORMER: power, low voltage, plate Pan Part T2-12127D	BZ T2-12127D	1	
T104		TRANSFORMER: power, low voltage, filament Pan Part T2-12126D	BZ T2-12126D	1	
T105		TRANSFORMER: high voltage (CRT supply) Pan Part T3043	CG ST-1334	1	
V101		ELECTRON TUBE: 5R4GYA Pan Part 5R4GYA	AK 5R4GYA	2	
V102		ELECTRON TUBE: 5R4GYA Pan Part 5R4GYA	AK 5R4GYA		
V103		ELECTRON TUBE: 6146 Pan Part 6146	AK 6146	2	
V104		ELECTRON TUBE: 6146 Pan Part 6146	AK 6146		
V105		ELECTRON TUBE: 12AT7 Pan Part 12AT7	AK 12AT7WA	4	
V106		ELECTRON TUBE: OA2 Pan Part OA2	AK OA2WA	6	
V107		ELECTRON TUBE: OG3 Pan Part OG3	AG OG3	1	
V108		ELECTRON TUBE: OA2 Pan Part OA2	AK OA2WA		
V109		ELECTRON TUBE: OA2 Pan Part OA2	AK OA2		
V110		ELECTRON TUBE: OA2 Pan Part OA2	AK OA2		
V111		ELECTRON TUBE: OA2 Pan Part OA2	AK OA2		
V112		ELECTRON TUBE: 6AS7GA Pan Part 6AS7GA	AK 6AS7GA	3	
V113		ELECTRON TUBE: 6AS7GA Pan Part 6AS7GA	AK 6AS7GA		
V114		ELECTRON TUBE: 12AX7 Pan Part 12AX7	AK 12AX7	5	
V115		ELECTRON TUBE: 12AX7 Pan Part 12AX7	AK 12AX7		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
V116		ELECTRON TUBE: 6AS7GA Pan Part 6AS7GA	AK 6AS7GA		
V117		ELECTRON TUBE: 12AX7 Pan Part 12AX7	AK 12AX7		
V118		ELECTRON TUBE: 12AX7 Pan Part 12AX7	AK 12AX7		
V119		ELECTRON TUBE: OA2 Pan Part OA2	AK OA2		
V120		ELECTRON TUBE: 5651 Pan Part 5651	AK 5651WA	1	
V121		ELECTRON TUBE: 6AR6 Pan Part 6AR6	AK 6AR6	1	
V122		ELECTRON TUBE: 1X2A/B Pan Part 1X2B	AK 1X2A/B	2	
V123		ELECTRON TUBE: 1X2A/B Pan Part 1X2B	AK 1X2A/B		
V301		ELECTRON TUBE: 6AF4A Pan Part 6AF4A	AK 6AF4A	3	
V302		ELECTRON TUBE: 6BM6 Pan Part 6BM6	AK 6BM6	1	
V304		ELECTRON TUBE: 5721 Pan Part 5721	AK 5721	1	
V401		ELECTRON TUBE: 5842 Pan Part 5842	AG 5842	4	
V402		ELECTRON TUBE: 5842 Pan Part 5842	AG 5842		
V405		ELECTRON TUBE: 5842 Pan Part 5842	AG 5842		
V406		ELECTRON TUBE: 5842 Pan Part 5842	AG 5842		
V601		ELECTRON TUBE: 6AQ5 Pan Part 6AQ5	AK 6AQ5	2	
V603		ELECTRON TUBE: 6AF4A Pan Part 6AF4A	AK 6AF4A		
V604		ELECTRON TUBE: 6AF4A Pan Part 6AF4A	AK 6AF4A		
V605		ELECTRON TUBE: 6AQ5 Pan Part 6AQ5	AK 6AQ5		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
V606		ELECTRON TUBE: 12AX7 Pan Part 12AX7	AK 12AX7		
V701		ELECTRON TUBE: 6J6 Pan Part 6J6	AK 6J6	1	
V702		ELECTRON TUBE: 12AU7 Pan Part 12AU7	AK 12AU7A	3	
V801		ELECTRON TUBE: 6922 Pan Part 6922	AG 6922	1	
V802		ELECTRON TUBE: 6688 Pan Part 6688	AG 6688	2	
V803		ELECTRON TUBE: 6688 Pan Part 6688	AG 6688		
V804		ELECTRON TUBE: 6J4 Pan Part 6J4	AK 6J4WA	1	
V805		ELECTRON TUBE: 12AT7 Pan Part 12AT7	AK 12AT7WA		
V806		ELECTRON TUBE: 6CB6A Pan Part 6CB6A	AK 6CB6A	10	
V1001		ELECTRON TUBE: 6CB6A Pan Part 6CB6A	AK 6CB6A		
V1002		ELECTRON TUBE: 6CB6A Pan Part 6CB6A	AK 6CB6A		
V1003		ELECTRON TUBE: 6CB6A Pan Part 6CB6A	AK 6CB6A		
V1004		ELECTRON TUBE: 6CB6A Pan Part 6CB6A	AK 6CB6A		
V1005		ELECTRON TUBE: 6AL5 Pan Part 6AL5	AK 6AL5	2	
V1006		ELECTRON TUBE: 6BA7 Pan Part 6BA7	AK 6BA7	1	
V1007		ELECTRON TUBE: 12AT7 Pan Part 12AT7	AK 12AT7WA		
V1008		ELECTRON TUBE: 6AH6 Pan Part 6AH6	AK 6AH6	2	
V1009		ELECTRON TUBE: 6AB4 Pan Part 6AB4	AK 6AB4	4	
V1101		ELECTRON TUBE: 6CB6A Pan Part 6CB6A	AK 6CB6A		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
V1102		ELECTRON TUBE: 6AB4 Pan Part 6AB4	AK 6AB4		
V1103		ELECTRON TUBE: 6CB6A Pan Part 6CB6A	AK 6CB6A		
V1104		ELECTRON TUBE: 6AB4 Pan Part 6AB4	AK 6AB4		
V1105		ELECTRON TUBE: 6CB6A Pan Part 6CB6A	AK 6CB6A		
V1106		ELECTRON TUBE: 6AH6 Pan Part 6AH6	AK 6AH6		
V1107		ELECTRON TUBE: 6AL5 Pan Part 6AL5	AK 6AL5		
V1201		ELECTRON TUBE: 12AY7 Pan Part 12AY7	AK 12AY7	1	
V1202		ELECTRON TUBE: 12AU7A Pan Part 12AU7A	AK 12AU7A		
V1203		ELECTRON TUBE: 6CB6A Pan Part 6CB6A	AK 6CB6A		
V1301		ELECTRON TUBE: 12AT7 Pan Part 12AT7	AK 12AT7WA		
V1302		ELECTRON TUBE: 6CB6A Pan Part 6CB6A	AK 6CB6A		
V1303		ELECTRON TUBE: 6AB4 Pan Part 6AB4	AK 6AB4		
V1304		ELECTRON TUBE: 12AU7A Pan Part 12AU7A	AK 12AU7A		
V1401		CATHODE RAY TUBE: 5ADP1 Pan Part 5ADP7 or 5ADP1	AK 5ADP1 or 5ADP7 per Mil-E-1/689B	1	
W101		LINE CORD ASSEMBLY: AC, 3 conductor Pan Part W3054-1	BZ W3054-1	1	
W301		CABLE ASSEMBLY: radio fre- quency with TM plug Type 2203 and Type N plug UG-536A/U RG-55/U coaxial cable 12" long Pan Part W-45-01 (for serial nos. 151-200)	BZ W-45-01	3	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
W301		CABLE ASSEMBLY: radio frequency, with 5115-TM plug and 5117N plug, RG-195/U coaxial cable 12'' long Pan Part W-83-12 (for serial nos. 201-250)	BZ W-83-12	3	
W301		CABLE ASSEMBLY: radio frequency, Pan Part P2151 and P2152 connectors, RG-55/U coaxial cable 12'' long Pan Part W-98-12 (for serial nos. 251 and above)	BZ W-98-12	3	
W303		CABLE ASSEMBLY: radio frequency, with TM plug Type 2203 and Type N plug UG-536A/U RG-55/U coaxial cable 12'' long Pan Part W-45-01 (for serial nos. 151-200)	BZ W-45-01		
W303		CABLE ASSEMBLY: radio frequency, with 5115 TM plug and 5117 N plug, RG-195/U coaxial cable 12'' long Pan Part W-83-12 (for serial nos. 201-250)	BZ W-83-12		
W303		CABLE ASSEMBLY: radio frequency, Pan Part P2151 and P2152 connectors, RG-55/U coaxial cable 12'' long Pan Part W-98-12 (for serial nos. 251 and above)	BZ W-98-12		
W305		CABLE ASSEMBLY: radio frequency with TM plug Type 2203 and Type N plug UG-536A/U RG-55/U coaxial cable 12'' long Pan Part W-45-01 (for serial nos 151-200)	BZ W-45-01		
W305		CABLE ASSEMBLY: radio frequency, with 5115 TM plug and 5117 N plug, RG-195/U coaxial cable 12'' long Pan Part W-83-12 (for serial nos. 201-250)	BZ W-83-12		
W305		CABLE ASSEMBLY: radio frequency, Pan Part P2151 and P2152 connectors, RG-55/U coaxial cable 12'' long Pan Part W-98-12 (for serial nos. 251 and above)	BZ W-98-12		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
W307		CABLE ASSEMBLY: radio frequency, two type 166A connectors, RG-55/U coaxial cable 12'' long Pan Part W-46-01 (for serial nos. 151-200)	BZ W-46-01	2	
W307		CABLE ASSEMBLY: radio frequency, two Type 5042 TNC plugs, RG-195/U coaxial cable 12'' long Pan Part W-84-12 (for serial nos. 201-250)	BZ W-84-12	2	
W307		CABLE ASSEMBLY: radio frequency, two Pan Part P2150 connectors, RG-55/U coaxial cable 12'' long Pan Part W99-12 (for serial nos. 251 and above)	BZ W99-12	2	
W309		CABLE ASSEMBLY: radio frequency, Type 2203 TM plug and Type 166A TNC plug, RG-55/U coaxial cable 12'' long Pan Part W44-01 (for serial nos 151-200)	BZ W44-01	3	
W309		CABLE ASSEMBLY: radio frequency, Type 5042 TNC plug and Type 5115 TM plug, RG-195/U coaxial cable 12'' long Pan Part W82-12 (for serial nos. 201-250)	BZ W82-12	3	
W309		CABLE ASSEMBLY: radio frequency, Pan Part P2150 and P2152 connectors, RG-55/U coaxial cable 12'' long Pan Part W97-12 (for serial nos. 251 and above)	BZ W97-12	3	
W311		CABLE ASSEMBLY: radio frequency, Type 2203 TM plug and Type 166A TNC plug, RG-55/U coaxial cable 12'' long Pan Part W44-01 (for serial nos. 151-200)	BZ W44-01		
W311		CABLE ASSEMBLY: radio frequency, Type 5042 TNC plug and Type 5115 TM plug, RG-195/U coaxial cable 12'' long Pan Part W82-12 (for serial nos. 201-250)	BZ W82-12		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
W311		CABLE ASSEMBLY: radio frequency, Pan Part P2150 and P2152 connectors, RG-55/U coaxial cable 12'' long Pan Part W97-12 (for serial nos. 251 and above)	BZ W97-12		
W313		CABLE ASSEMBLY: radio frequency, Type 2203 TM plug and Type 166A TNC plug, RG-55/U coaxial cable 12'' long Pan Part W44-01 (for serial nos. 151-200)	BZ W44-01		
W313		CABLE ASSEMBLY: radio frequency, Type 5042 TNC plug and Type 5115 TM plug, RG-195/U coaxial cable 12'' long Pan Part W82-12 (for serial nos. 201-250)	BZ W82-12		
W313		CABLE ASSEMBLY: radio frequency, Pan Part P2150 and P2152 connectors, RG-55/U coaxial cable 12'' long Pan Part W97-12 (for serial nos. 251 and above)	BZ W97-12		
W315		CABLE ASSEMBLY: radio frequency, two Type 166A connectors, RG-55/U coaxial cable 12'' long Pan Part W46-01 (for serial nos. 151-200)	BZ W46-01		
W315		CABLE ASSEMBLY: radio frequency, two Type 5042 TNC plugs, RG-195/U coaxial cable 12'' long Pan Part W84-12 (for serial nos. 201-250)	BZ W84-12		
W315		CABLE ASSEMBLY: radio frequency, two Pan Part P2150 connectors, RG-55/U coaxial cable 12'' long Pan Part W99-12 (for serial nos. 251 and above)	BZ W99-12		
W401		CABLE ASSEMBLY: radio frequency, two SELECTRO #3030 connectors, RG-195/U coaxial cable 41'' long Pan Part W39-08 (for serial nos. 151-250)	BZ W39-08	2	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
W401		CABLE ASSEMBLY: radio frequency, Pan Part P2116 and P2123 connectors, RG-195/U coaxial cable 38" long Pan Part W47-38 (for serial nos. 251-300)	BZ W47-38	1	
W401		CABLE ASSEMBLY: radio frequency, Pan Part P2157 and P2158 connectors, RG-195/U coaxial cable 38" long Pan Part W113-38 (for serial nos. 301-375)	BZ W113-38	1	
W402		CABLE ASSEMBLY: radio frequency, two SELECTRO #3030 connectors, RG-195/U coaxial cable 7" long Pan Part W39-06 (for serial nos. 151-250)	BZ W39-06	2	
W402		CABLE ASSEMBLY: radio frequency, Pan Part P2116 and P2123 connectors, RG-195/U coaxial cable 6" long Pan Part W47-6 (for serial nos. 251-300)	BZ W47-6	2	
W402		CABLE ASSEMBLY: radio frequency, Pan Part P2157 and P2158 connectors, RG-195/U coaxial cable 6" long Pan Part W113-6 (for serial nos. 301-375)	BZ W113-6	2	
W403		CABLE ASSEMBLY: radio frequency, two SELECTRO #3030 connectors, RG-195/U coaxial cable 7-1/2" long Pan Part W39-04 (for serial nos. 151-250)	BZ W39-04	1	
W403		CABLE ASSEMBLY: radio frequency, Pan Part P2116 and P2123 connectors, RG-195/U coaxial cable 6-1/2" long Pan Part W47-6P5 (for serial nos. 251-300)	BZ W47-6P5	1	
W403		CABLE ASSEMBLY: radio frequency, Pan Part P2157 and P2158 connectors, RG-195/U coaxial cable 6-1/2" long Pan Part W113-6P5 (for serial nos. 301-375)	BZ W113-6P5	1	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
W404		CABLE ASSEMBLY: radio frequency, two SELECTRO #0303 connectors, RG-195/U coaxial cable 4'' long Pan Part W39-01 (for serial nos. 151-250)	BZ W39-01	1	
W404		CABLE ASSEMBLY: radio frequency, two Pan Part P2123 connectors, RG-195/U coaxial cable 7-1/2'' long Pan Part W39-4 (for serial nos. 251-300)	BZ W39-4	1	
W404		CABLE ASSEMBLY: radio frequency, two Pan Part P2158 connectors, RG-195/U coaxial cable 7-1/2'' long Pan Part W114-4 (for serial nos. 301-375)	BZ W114-4	1	
W405		CABLE ASSEMBLY: radio frequency, two SELECTRO #3030 connectors, RG-195/U coaxial cable 5'' long Pan Part W39-02 (for serial nos. 151-250)	BZ W39-02	1	
W405		CABLE ASSEMBLY: radio frequency, two Pan Part P2123 connectors, RG-195/U coaxial cable 7'' long Pan Part W39-5 (for serial nos. 251-300)	BZ W39-5	1	
W405		CABLE ASSEMBLY: radio frequency, two Pan Part P2158 connectors, RG-195/U coaxial cable 7'' long Pan Part W114-5 (for serial nos. 301-375)	BZ W114-5	1	
W601		CABLE ASSEMBLY: radio frequency, two SELECTRO #3030 connectors, RG-195/U coaxial cable 7'' long Pan Part W39-05 (for serial nos. 151-250)	BZ W39-05	1	
W601		CABLE ASSEMBLY: radio frequency, Pan Part P2116 and P2123 connectors, RG-195/U coaxial cable 5'' long Pan Part W47-5 (for serial nos. 251-300)	BZ W47-5	1	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
W601		CABLE ASSEMBLY: radio frequency, Pan Part P2157 and P2158 connectors, RG-195/U coaxial cable 5'' long Pan Part W113-5 (for serial nos. 301-375)	BZ W113-5	1	
W602		CABLE ASSEMBLY: radio frequency, SELECTRO #3030 connector and open end, RG-195/U coaxial cable 35-1/2'' long Pan Part W41-04 (for serial nos. 151-250)	BZ W41-04	1	
W602		CABLE ASSEMBLY: radio frequency, Pan Part P2116 connector and open end, RG-195/U coaxial cable 37'' long Pan Part W102-37 (for serial nos. 251-300)	BZ W102-37	2	
W602		CABLE ASSEMBLY: radio frequency, Pan Part P2157 connector and open end. RG-195/U coaxial cable 37'' long Pan Part W109-37 (for serial nos. 301-375)	BZ W109-37	2	
W701		CABLE ASSEMBLY: radio frequency, two SELECTRO #3030 connectors, RG-195/U coaxial cable 26'' long Pan Part W39-07 (for serial nos. 151-250)	BZ W39-07	1	
W701		CABLE ASSEMBLY: radio frequency, two Pan Part P2123 connectors, RG-195/U coaxial cable 26'' long Pan Part W39-26 (for serial nos. 251-300)	BZ W39-26	1	
W701		CABLE ASSEMBLY: radio frequency, two Pan Part P2158 connectors, RG-195/U coaxial cable 26'' long Pan Part W114-36 (for serial nos. 301-375)	BZ W114-36	1	
W702		CABLE ASSEMBLY: radio frequency, two SELECTRO #3030 connectors, RG-195/U coaxial cable 53'' long Pan Part W39-010 (for serial nos. 151-250)	BZ W39-010	2	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
W702		CABLE ASSEMBLY: radio frequency, two Pan Part P2123 connectors, RG-195/U coaxial cable 55" long Pan Part W39-53 (for serial nos. 251-300)	BZ W39-53	1	
W702		CABLE ASSEMBLY: radio frequency, two Pan Part P2158 connectors, RG-195/U coaxial cable 55" long Pan Part W114-53 (for serial nos. 301-375)	BZ W114-53	1	
W703		CABLE ASSEMBLY: radio frequency, SELECTRO #3030 and #3033 connectors, RG-195/U coaxial cable 29-1/2" long Pan Part W40-03 (for serial nos. 151-200)	BZ W40-03	1	
W703		CABLE ASSEMBLY: radio frequency, Pan Part J2088 and P2123 connectors, RG-195/U coaxial cable 21" long Pan Part W40-21 (for serial nos. 251-300)	BZ W40-21	2	
W703		CABLE ASSEMBLY: radio frequency, Pan Part P2159 and P2158 connectors, RG-195/U coaxial cable 21" long Pan Part W111-21 (for serial nos. 301-375)	BZ W111-21	2	
W801		CABLE ASSEMBLY: radio frequency, SELECTRO #3030 and #3035 connectors, RG-195/U coaxial cable 11" long Pan Part W47-01 (for serial nos. 151-250)	BZ W47-01	1	
W801		CABLE ASSEMBLY: radio frequency, Pan Part P2116 and P2123 connectors, RG-195/U coaxial cable 11" long Pan Part W47-11 (for serial nos. 251-300)	BZ W47-11	1	
W801		CABLE ASSEMBLY: radio frequency, Pan Part P2157 and P2158 connectors, RG-195/U coaxial cable 11" long Pan Part W113-11 (for serial nos. 301-375)	BZ W113-11	1	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
W802		CABLE ASSEMBLY: radio frequency, two SELECTRO #3030 connectors, RG-195/U coaxial cable 6-1/2" long Pan Part W39-03 (for serial nos. 151-250)	BZ W39-03	1	
W802		CABLE ASSEMBLY: radio frequency, Pan Part P2116 and P2123 connectors, RG-195/U coaxial cable 6" long Pan Part W47-6 (for serial nos. 251-300)	BZ W47-6	1	
W802		CABLE ASSEMBLY: radio frequency, Pan Part R2157 and P2158 connectors, RG-195/U coaxial cable 6" long Pan Part W113-6 (for serial nos. 301-375)	BZ W113-6	1	
W803		CABLE ASSEMBLY: radio frequency, SELECTRO #3030 connector and open end. RG-195/U coaxial cable 38½" long Pan Part W41-02 (for serial nos. 151-250)	BZ W41-02	1	
W803		CABLE ASSEMBLY: radio frequency, Pan Part P2116 connector and open end. RG-195/U coaxial cable 37" long Pan Part W102-37 (for serial nos. 251-300)	BZ W102-37	1	
W803		CABLE ASSEMBLY: radio frequency, Pan Part P2157 connector and open end. RG-195/U coaxial cable 37" long Pan Part W109-37 (for serial nos. 301-375)	BZ W109-37	1	
W1001		CABLE ASSEMBLY: radio frequency, two SELECTRO #3030 connectors, RG-195/U coaxial cable 41" long Pan Part W39-08 (for serial nos. 151-200)	BZ W39-08	1	
W1001		CABLE ASSEMBLY: radio frequency, two SELECTRO #3030 connectors RG-195/U coaxial cable 53" long Pan Part W39-010 (for serial nos. 201-250)	BZ W39-010	1	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
W1001		CABLE ASSEMBLY: radio frequency, Pan Part P2116 and P2123 connectors, RG-195/U coaxial cable 53" long Pan Part W47-53 (for serial nos. 251-300)	BZ W47-53	1	
W1001		CABLE ASSEMBLY: radio frequency, Pan Part P2157 and P2158 connectors, RG-195/U coaxial cable 53" long Pan Part W113-53 (for serial nos. 301-375)	BZ W113-53	1	
W1002		CABLE ASSEMBLY: radio frequency, two SELECTRO #3030 connectors, RG-195/U coaxial cable 42-1/2" long Pan Part W39-09 (for serial nos. 151-250)	BZ W39-09	1	
W1002		CABLE ASSEMBLY: radio frequency, two Pan Part P2123 connectors, RG-195/U coaxial cable 40" long Pan Part W39-40 (for serial nos. 251-300)	BZ W39-40	1	
W1002		CABLE ASSEMBLY: radio frequency, two Pan Part P2158 connectors, RG-195/U coaxial cable 40" long Pan Part W114-40 (for serial nos. 301-350)	BZ W114-40	1	
W1003		CABLE ASSEMBLY: radio frequency, SELECTRO #3030 and #3033 connectors, RG-195/U coaxial cable 33" long Pan Part W40-02 (for serial nos. 151-250)	BZ W40-02	4	
W1003		CABLE ASSEMBLY: radio frequency, Pan Part J2088 and P2123 connectors, RG-195/U coaxial cable 33" long Pan Part W40-32 (for serial nos. 251-300)	BZ W40-32	4	
W1003		CABLE ASSEMBLY: radio frequency, Pan Part P2159 and P2158 connectors, RG-195/U coaxial cable 33" long Pan Part W111-32 (for serial nos. 301-350)	BZ W111-32	4	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
W1101		CABLE ASSEMBLY: radio frequency, two SELECTRO #3030 connectors, RG-195/U coaxial cable 8" long Pan Part W39-06 (for serial nos. 151-250)	BZ W39-06	1	
W1101		CABLE ASSEMBLY: radio frequency, two Pan Part P2116 connectors, RG-195/U coaxial cable 5-1/2" long Pan Part W103-5P5 (for serial nos. 251-300)	BZ W103-5P5	1	
W1101		CABLE ASSEMBLY: radio frequency, two Pan Part P2157 connectors, RG-195/U coaxial cable 5-1/2" long Pan Part W110-5P5 (for serial nos. 301-350)	BZ W110-5P5	1	
W1102		CABLE ASSEMBLY: radio frequency, SELECTRO #3030 and #3033 connectors, RG-195/U coaxial cable 21" long Pan Part W40-01 (for serial nos. 151-250)	BZ W40-01	2	
W1102		CABLE ASSEMBLY: radio frequency, Pan Part J2088 and P2123 connectors, RG-195/U coaxial cable 21" long Pan Part W40-21 (for serial nos. 251-300)	BZ W40-21	2	
W1102		CABLE ASSEMBLY: radio frequency, Pan Part P2159 and P2158 connectors, RG-195/U coaxial cable 21" long Pan Part W111-21 (for serial nos. 301-350)	BZ W111-21	2	
W1103		CABLE ASSEMBLY: radio frequency, SELECTRO #3030 connector and open end, RG-195/U coaxial cable 54" long Pan Part W41-03 (for serial nos. 151-250)	BZ W41-03	1	
W1103		CABLE ASSEMBLY: radio frequency, Pan Part P2123 connector and open end, RG-195/U coaxial cable 54" long Pan Part W41-54 (for serial nos. 251-300)	BZ W41-54	4	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
W1103		CABLE ASSEMBLY: radio frequency, Pan Part P2158 connector and open end, RG-195/U coaxial cable 54" long Pan Part W112-54 (for serial nos. 301-350)	BZ W112-54	4	
W1201		CABLE ASSEMBLY: radio frequency, SELECTRO #3030 connector and open end, RG-195/U coaxial cable 29" long Pan Part W41-01 (for serial nos 151-250)	BZ W4101	1	
W1201		CABLE ASSEMBLY: radio frequency, Pan Part P2123 connector and open end, RG-195/U coaxial cable 29" long Pan Part W41-29 (for serial nos. 251-300)	BZ W41-29	1	
W1201		CABLE ASSEMBLY: radio frequency, Pan Part P2158 connector and open end, RG-195/U coaxial cable 29" long Pan Part W112-29 (for serial nos. 301-350)	BZ W112-29	1	
W1203		CABLE ASSEMBLY: radio frequency, Pan Part P2123 connector and open end, RG-195/U coaxial cable 54" long Pan Part W41-54 (for serial nos. 251-300)	BZ W41-54	4	
W1203		CABLE ASSEMBLY: radio frequency, Pan Part P2158 connector and open end, RG-195/U coaxial cable 54" long Pan Part W112-54 (for serial nos. 301-350)	BZ W112-54		
W1205		CABLE ASSEMBLY: radio frequency, Pan Part J2088 and P2123 connectors, RG-195/U coaxial cable 33" long Pan Part W40-32 (for serial nos. 251-300)	BZ W40-32	4	
W1205		CABLE ASSEMBLY: radio frequency, Pan Part P2159 and P2158 connectors, RG-195/U coaxial cable 33" long Pan Part W111-32 (for serial nos. 301-350)	BZ W111-32		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
W1207		CABLE ASSEMBLY: radio frequency, Pan Part P2123 connector and open end, RG-195/U coaxial cable 54'' long Pan Part W41-54 (for serial nos. 251-300)	BZ W41-54		
W1207		CABLE ASSEMBLY: radio frequency, Pan Part P2158 connector and open end, RG-195/U coaxial cable 54'' long Pan Part W112-54 (for serial nos. 301-350)	BZ W112-54		
W1209		CABLE ASSEMBLY: radio frequency, Pan Part J2088 and P2123 connectors, RG-195/U coaxial cable 33'' long Pan Part W40-32 (for serial nos. 251-300)	BZ W40-32		
W1209		CABLE ASSEMBLY: radio frequency, Pan Part P2159 and P2158 connectors, RG-195/U coaxial cable 33'' long Pan Part W111-32 (for serial nos. 301-350)	BZ W111-32		
W1301		CABLE ASSEMBLY: radio frequency, Pan Part P2123 connector and open end. RG-195/U coaxial cable 54'' long Pan Part W41-54 (for serial nos. 251-300)	BZ W41-54		
W1301		CABLE ASSEMBLY: radio frequency, Pan Part P2158 connector and open end, RG-195/U coaxial cable 54'' long Pan Part W112-54 (for serial nos. 301-350)	BZ W112-54		
W1307		CABLE ASSEMBLY: radio frequency, Pan Part J2088 and P2123 connectors, RG-195/U coaxial cable 33'' long Pan Part W40-32 (for serial nos. 251-300)	BZ W40-32		
W1307		CABLE ASSEMBLY: radio frequency, Pan Part P2159 and P2158 connectors, RG-195/U coaxial cable 33'' long Pan Part W111-32 (serial nos. 301-350)	BZ W111-32		

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
Y 1001		FILTER: crystal unit, 68.5 mc Pan Part Y3010	DI 9081001 Type 2001	1	
Y 1101		FILTER: crystal unit, 6.5 mc Pan Part Y3009A	DI 8061302A Type 2001	1	
Y 1102		FILTER: crystal unit, 6.5 mc Pan Part Y3009B	DI 8061302B Type 2001	1	
Z301		TUNED LINE: 160-580 mc part of triode oscillator ground plane assembly. Replace as a unit Pan Part A4-11228	BZ A4-11228		
Z302		Cavity, tuned line 1 - 4.5 kmc Pan Part A4-10828 consists of: Choke assembly Pan Part A2-10646 (Fig. V-30a, Ref.9) Barrel assembly Pan Part A2-10808 (Fig. V-30a, Ref. 10) End Bell assembly Pan Part A3-10811 (Fig. V-30a, Ref. 1) Nut, retainer, tube Pan Part A1-10812 (Fig. V-30a, Ref. 2) Nut, lock, repeller Pan Part A2-10813 Retainer, tube Pan Part A2-10814 (Fig. V-30a, Ref. 3) Spring contact Pan Part A1-10815 (Fig. V-30a, Ref. 3) Center Conductor assembly Pan Part A2-10816 (Fig. V-30a, Ref. 8) Push Rod assembly Pan Part A2-10824 (Fig. V-30a, Ref. 5)	BZ A4-10828	1	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
Z303		Probe assembly Pan Part W27-6-7/8 (Fig. V-30a, Ref. 4) Nut, probe, lock Pan Part A1-13695 CAVITY, tuned line, 4.5 - 11 kmc Pan Part A4-11033 consists of: Choke assembly Pan Part A3-11022 (Fig. V-31a, Ref. 11) Rod assembly Pan Part A2-11016 Barrel assembly Pan Part A3-11017 (Fig. V-31a, Ref. 12) Nut, repeller Pan Part A1-11022 Nut, lock, center conductor Pan Part A2-11023 Nut, retainer, tube Pan Part A2-11253 Push Rod assembly Pan Part A2-11318 (Fig. V-31a, Ref. 7) End Bell assembly Pan Part A3-11322 (Fig. V-31a, Ref. 1) Insert Pan Part A2-11501 Tube clamp Pan Part A2-11502 Insert contact Pan Part A2-11503 Taper lock Pan Part A2-11504 Probe assembly Pan Part W28-14-1/8 (Fig. V-31a, Ref. 6)	BZ A4-11033	1	

List of Replaceable Parts for Model SPA-4a

Circuit Ref. Symbol	Stock No.	Description	Mfr. & Mfrs. No.	Qty. In Set	Qty. 3 Mo. Opn.
Z304		MIXER: 10 mc - 11 kmc Pan Part Z1025	BZ Z1025	1	
Z305		MIXER ASSEMBLY: Ku band Pan Part Z1009	BZ Z1009	1	
Z306		MIXER ASSEMBLY: K band Pan Part Z1010	BZ Z1010	1	
Z307		MIXER ASSEMBLY: Ka band Pan Part Z1011	BZ Z1011	1	
Z309		MATCHING NETWORK: Input - BNC right angle male 70 mc bandpass centered Output - Straight TNC female at 160 mc $\pm 1/2$ db from flat max Pan Part Z1023	BZ Z1023	1	
Z1001		TRANSFORMER: if, 6.5 mc Pan Part ZN8400	BZ ZN8400	4	
Z1101		TRANSFORMER: if, 6.5 mc Pan Part ZN8400	BZ ZN8400		
Z1102		TRANSFORMER: if, 6.5 mc Pan Part ZN8400	BZ ZN8400		
Z1103		TRANSFORMER: if, 6.5 mc Pan Part ZN8400	BZ ZN8400		
Z1104		TRANSFORMER: if, 6.5 mc Pan Part ZN8413	BZ ZN8413	1	

SPECTRUM ANALYZER Model SPA-4a

LIST OF MANUFACTURERS CODE LETTERS

AA	Advance Relays Div. of Elgin National Watch Co.
AB	Aerovox Corporation
AC	Aircom, Inc.
AD	Alden Products, Inc.
AE	Allen-Bradley Company
AF	The Allen Manufacturing Company
AG	Amperex Electronics Corp.
AH	Amperite Company, Inc.
AJ	Amphenol Electronics Corp.
AK	Any brand tube meeting EIA standards
AL	Any miniature lamp manufacturer
AM	Arrow-Hart and Hegeman
AN	Audio Devices, Inc.
AP	Automatic Metal Products Corp.
AQ	The Bristol Co.
AR	Cannon Electric Co.
AS	Centralab Div. Globe-Union Inc.
AT	Chicago Telephone Supply Co.
AU	Continental Carbon, Inc.
AV	Cornell-Dubilier Electric Co.
AW	Cornish Wire Co., Inc.
AZ	FXR, Div. of Danbury-Knudsen, Inc.
BA	Dialight Corporation
BB	Eldema Corporation
BC	Electro Motive Manufacturing Corp.
BD	Erie Resistor Corp.
BE	The Filtron Company, Inc.
BF	Filohm Corporation
BG	General Communications Company
BH	The Gudeman Company
BJ	Hammarlund Manufacturing Co., Inc.
BK	Harvey Hubbell, Inc.
BL	Heterington, Inc.
BM	Industrial Products Co.
BN	Industrial Products Co. Div. of Amphenol Electronics Corp.
BP	International Rectifier Corp.
BQ	International Resistance Co.
BR	J.F.D. Electronics Company
BS	E. F. Johnson Company
BT	Littelfuse

LIST OF MANUFACTURERS CODE LETTERS (cont.)

BU	Micro Switch Div. Minneapolis Honeywell Regulator Co.
BV	Microdot, Inc.
BW	Millen Manufacturing Co.
BX	J. W. Miller Company
BY	Ohmite, Inc.
BZ	Singer Metrics Division, The Singer Manufacturing Company
CA	Sangamo Electric Co.
CB	Sarkes Tarzian, Inc.
CC	Sealectro Corporation
CD	Sprague Electric Company
CE	Sprague Products Company
CF	Stackpole Carbon Company
CG	Sterling Transformer Corp.
CH	Sylvania Electric Products, Inc.
CJ	Var-L Company
CK	Walsco Electronics Manufacturing Co.
CL	Ward Leonard Electric Co.
CM	Wilco Corporation
CN	Winchester Electronics, Inc.
CP	Victory Engineering Co.
CQ	Kurman Electric Co.
CR	CGS Laboratories
CS	Transistor Electronics Corp.
CT	General Electric Co.
CU	International Instrument, Inc.
CV	Eastern Air Devices, Inc.
CW	Tru-Ohm Products, Div., Model Engineering and Mfg.
CX	Dage Electric Co., Inc.
CY	Jeffers Electronics Div., Speer Carbon Co.
CZ	Kings Electronics, Inc.
DA	Redmond Co., Inc.
DB	General RF Fittings, Inc.
DC	Solar Mfg. Corp.
DD	Kulka Electric Mfg. Co., Inc.
DE	Eagle Electric Co.
DF	Trak Electric Co.
DG	R.F. Products, Div. Amphenal-Borg.
DH	Rye Sound Corp.
DI	Piezo Crystal Co.
DJ	Control Switch, Div. of Control Co. of America

REPAIR AND MAINTENANCE FORM

COMPANY _____ DATE _____

ATTENTION _____

PHONE _____

INSTRUMENT DATA

MODEL _____ TYPE _____
SERIAL NUMBERS: ANALYZER _____ POWER SUPPLY _____
ACCESSORIES _____

(IF THE FRONT PANEL SERIAL NUMBER DIFFERS FROM THE SERIAL NUMBER ON THE PATENT LABEL ON THE REAR OF THE CHASSIS, PLEASE LIST PATENT LABEL SERIAL NUMBER)

REPAIR DATA

1. TYPE OF TROUBLE* _____

2. TEST INSTRUMENTS USED FOR MAINTENANCE AND TROUBLE SHOOTING _____

3. APPROXIMATE DATE INSTRUMENT PLACED IN OPERATION _____
4. APPROXIMATE NUMBER OF HOURS INSTRUMENT IN OPERATION SINCE ITEM 3 _____

*Please include information on symptoms, measurements taken, suspected location of trouble, maintenance action taken, and any other relevant data.

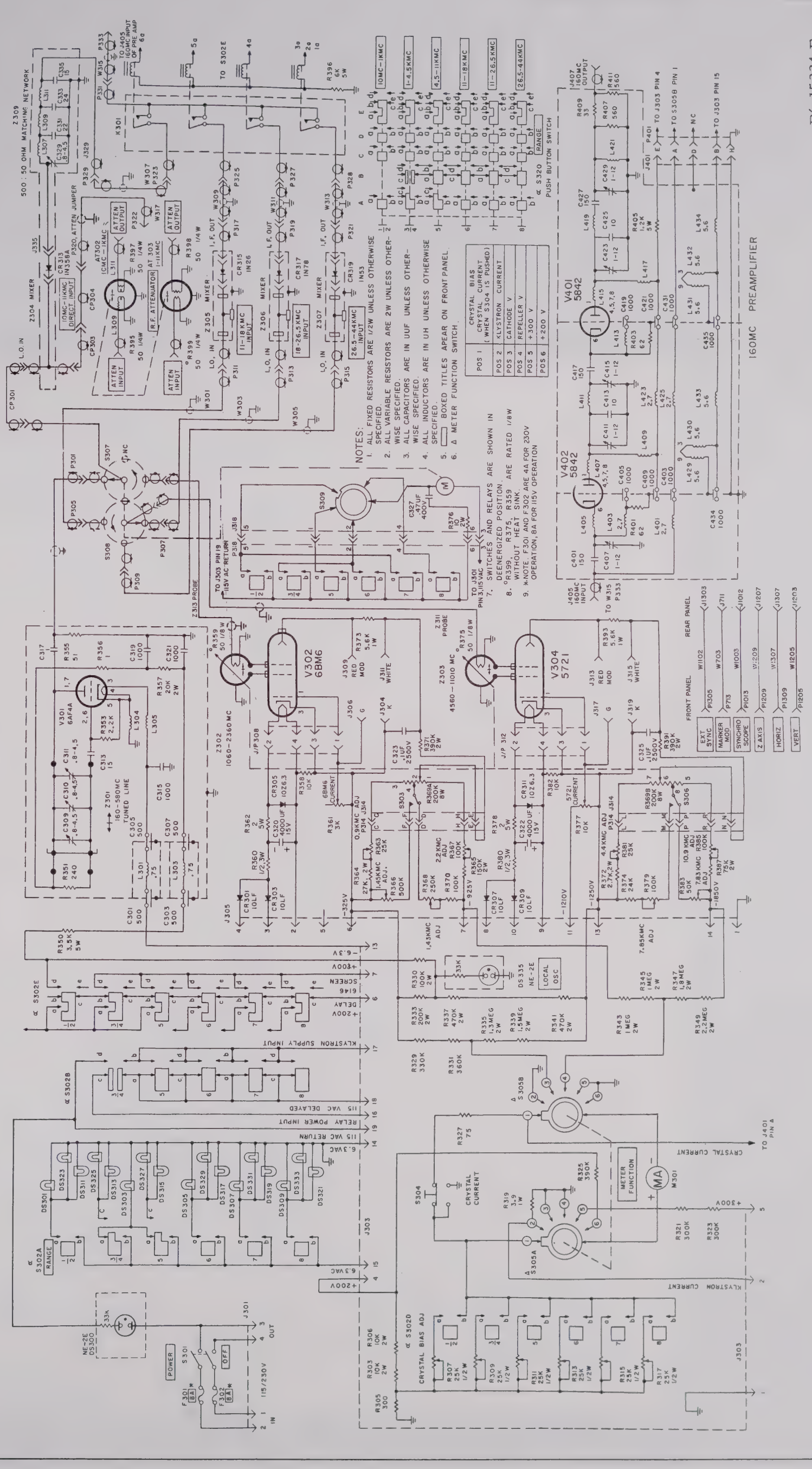


5. HAS MAINTENANCE ACTION PREVIOUSLY BEEN REQUESTED? _____
6. RESULTS? _____
7. COMMENTS:

For repair or maintenance assistance, fill out this form as completely as possible and send to:

SERVICE DEPARTMENT
SINGER METRICS DIVISION
THE SINGER MANUFACTURING CO.
915 PEMBROKE AVENUE
BRIDGEPORT 8, CONNECTICUT

Upon receipt of this information our Service Department will send you service data or shipping instructions. Upon receipt of shipping instructions forward the instrument to the factory prepaid. If requested, an estimate of charges will be made before work begins.



- NOTES:
1. ALL FIXED RESISTORS ARE 1/2W UNLESS OTHERWISE SPECIFIED.
 2. ALL VARIABLE RESISTORS ARE 2W UNLESS OTHERWISE SPECIFIED.
 3. WISE SPECIFIED.
 4. WISE SPECIFIED.
 5. ALL CAPACITORS ARE IN UUF UNLESS OTHERWISE SPECIFIED.
 6. ALL INDUCTORS ARE IN UH UNLESS OTHERWISE SPECIFIED.
 7. BOXED TITLES APPEAR ON FRONT PANEL.
 8. Δ METER FUNCTION SWITCH.
7. SWITCHES AND RELAYS ARE SHOWN IN DEENERGIZED POSITION.
8. R339, R375, R359 ARE RATED 1/8W WITHOUT HEAT SINK.
9. *NOTE: F301 AND F302 ARE 4A FOR 230V OPERATION, 8A FOR 115V OPERATION.
- | POS | CRYSTAL BIAS |
|-------|---------------------------------------|
| POS 1 | CRYSTAL CURRENT (WHEN S304 IS PUSHED) |
| POS 2 | CRYSTAL CURRENT |
| POS 3 | CATHODE V |
| POS 4 | REFLECTOR V |
| POS 5 | +300 V |
| POS 6 | +200 V |

P6-15224 F

MP MASTER



MA30817